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ABSTRACT

This document presents the hearing before the Committee on Science in the House of Representatives on why and how math and science should be learned. It includes oral opening statements by various House representatives. Appendix 1 presents written opening statements from members of the subcommittee on basic research. Appendix 2 features written testimony, biographies, financial disclosures, and answers to post-hearing questions. Materials for the record are listed in the third appendix and include "Preparing Our Children: Math and Science Education in the National Interest" and "Winning the Skills Race: A Council on Competitiveness Report on Mathematics and Science Education". (ASK)

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WHY AND HOW YOU SHOULD LEARN MATH AND SCIENCE

HEARING

BEFORE THE

COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES
ONE HUNDRED SIXTH CONGRESS
FIRST SESSION

MARCH 17, 1999

Serial No. 106–21

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HEARING ON WHY AND HOW YOU SHOULD LEARN MATH AND SCIENCE

WEDNESDAY, MARCH 17, 1999

House of Representatives,
Committee on Science,
Washington, DC.

The Committee met, pursuant to notice, at 10:00 a.m., in room 2318, Rayburn House Office Building, Hon. F. James Sensenbrenner (Chairman of the Committee) presiding.

Chairman Sensenbrenner [presiding]. The Committee on Science will come to order.

Today, I want to welcome everyone here today for the first in a series of hearings the Science Committee will be holding on science, math, engineering, and technology education.

As you may know, last year I charged Congressman Ehlers with developing an approach to a new national science policy. As a result of over a year's work, the Committee released the study, "Unlocking Our Future: Toward a New National Science Policy," a major focus of which is math and science education. As the report notes, math and science education is the road that will ensure American preeminence in technology and prepare American students to be able employees, smart consumers, and engaged citizens. I am pleased that the Committee is following up on this aspect of the Science Policy Study, as education is one of the most important issues we must address.

By now it is old news that U.S. students are not performing to the level of their peers around the world. In fact, U.S. students perform near the bottom. Clearly, American children are not receiving an adequate education in math and science, and we as a Nation should be concerned. We can and must do a better job of preparing our young people for the 21st century and we have an obligation to see that students receive the education they will need if they are to compete and win in the global marketplace of the future.

This series of hearings will serve as a comprehensive examination of current science and math education, the directions science and math education may take in the future, and programmatic reforms that may be necessary to ensure graduates of U.S. schools are well prepared. The examination will require assessing the current situation and understanding the specific weaknesses in our education systems. The most technologically-advanced economy in the world requires the most scientifically-literate workforce on the planet.

I am pleased that my colleague Vern Ehlers of Michigan will be chairing this series of hearings and taking the lead in this most important issue. Before I turn the gavel over to Congressman Ehlers, I would like to thank the witnesses for appearing before us today and look forward to reading their testimony.

Chairman SENSENBRENNER. Would the gentleman from California like to lead off on the Democratic side or does he believe in "ladies first" and should I recognize the gentlewoman from Texas?

Mr. BROWN. Thank you very much for your consideration, Mr. Chairman. I would prefer you recognize the lady first.

Chairman SENSENBRENNER. The gentlewoman from Texas is recognized for an opening statement.

Ms. EDDIE BERNICE JOHNSON of Texas. Thank you very much, Mr. Chairman. I really appreciate this hearing and I appreciate the work of Mr. Ehlers.

During last Congress, the Science Committee held several hearings. Some of the people here testified and I would like to welcome this panel and look forward to a good exchange.

The status of K–12 science and math education—we are seeking ways to improve student performance in these subjects. I am pleased to join Vice Chairman Ehlers today in initiating a new series of science education hearings, which I hope will lay the groundwork for some specific legislative initiatives.

The basic question raised by this hearing is, why is it important that students learn science and math? To those of us on the Science Committee, the answer is clear: in the past, concerns about science education were motivated largely by the goal of ensuring a full pipeline of students moving toward careers in science and technology but the realization that technology now infuses more and more aspects of daily life leads to the conclusion that all citizens need a basic grounding in science and math to function in an increasingly complex world and to lead fulfilling lives.

Most workplaces are becoming increasingly technological. While our society is becoming increasingly diverse, we are running the risk of a widening gulf between those with the training to thrive in this new work environment and those lacking the basic skills to qualify for the high-tech workplace.

The Nation must take advantage of the human resource potential of all of our people if we are to succeed in international economic competition of the 21st century. This will require that reform efforts in science and math education seek to engage and cultivate the interest of all children. There is much evidence that young children are naturally interested in science and that grade school students in the United States perform well in science and math.

This was shown to be the case in recent results of the Third International Math and Science Study, known as TIMSS. U.S. students at the fourth grade level were near the top in this international comparison. However, the picture changes for the worse as students move through the school system. By middle school—again, the TIMSS findings—U.S. students have drifted down to the average performance level of the international comparison, well below most of our major economic competitors. And, by the terminal year of high school, U.S. students are near the bottom in the ranking of science and math performance. This study gathered extensive data on teaching strategies, curriculum materials, teacher development, and many other aspects of a school system of the various countries.

At today's hearing we hope to explore whether the analysis of this data has led to any conclusions that could inform educational reform efforts in the United States. In general, we are interested in the views of our witnesses on ways that Federal education programs can contribute more effectively to the goal of improving science and math education and particularly seek their views on possible unmet needs for support of relevant research and demonstration activities. Any recommendations that you may have would be welcome.

Mr. Chairman, I congratulate you for calling this hearing and join in welcoming all of our witnesses and look forward to it. I thank you.

Chairman EHLERS [presiding]. Thank you for your opening statement.

I will proceed with mine and then we will recognize the Ranking Member, the gentleman from California, for his opening statement and all the remaining ones will be simply entered on the record following the standard procedure of this Committee.

I am very pleased to welcome everyone to the first in a series of hearings we plan to have on examining mathematics and science education efforts within the United States. As most of you know, and as Chairman Sensenbrenner told you a minute ago, I was asked by Speaker Gingrich and Chairman Sensenbrenner to head up a science policy study during the last Congress. This resulted in the report, "Unlocking Our Future: Toward a New National Science Policy," about the vital need of our Nation to improve and maintain its efforts in science and, particularly, to fortify our system of mathematics and science education from preschool through graduate school.

Education is the cornerstone of a national resource, the intellectual capacity of our children. Our K–12 education systems serve three main purposes in that regard: it is responsible for preparing future scientists and engineers for further study in college and graduate school—that is number one; secondly, it provides a foundation for those who will enter the workforce in other capacities—in other words, workplace readiness; and third—and equally important—it provides scientific and technical understanding so that the citizens of our land may make informed decisions as consumers and voters.

We must continuously and diligently nurture future generations in order to provide them the opportunity to contribute and prosper in the technology-based world of tomorrow. Recent assessments of students performance—as you have heard repeatedly and also heard just a few moments ago from Congresswoman Eddie Bernice Johnson—our performance in science and math showed that although our fourth graders did relatively well in both math and science, our twelfth grade students are far from the goals set by the Bush Administration and the 50 state governors some years ago about being first in the world by the year 2000.

We have much to be proud of in our national educational system but we ought always to be seeking to address our weaknesses and to improve our performance. By combining the lessons learned through the TIMSS analysis with the many discussions we have had on this subject in the past, we can begin to address the steps necessary to rectify the deficiencies in our educational system and effectively pursue our goals.

In addition to the need to stimulate future curiosity and innovation in science and technology, I believe that it is not only for the sake of learning math and science fundamentals that these subjects must be taught—and this is a very important point often overlooked. In today's world, these disciplines have a large and direct impact on many aspects of our lives. Learning the inquiry-driven process underlying math and science principles helps develop the human intellect, aiding the learning of other, seemingly unrelated subjects.

To enter the workforce in jobs ranging from an office worker to an aerospace engineer, technical competence and problem-solving skills—which are the fruits of a solid foundation in math and science—are essential to exercising our roles effectively. In a recent study by Thomas Burkman entitled, "The Role of Technology in Future Schools," it is pointed out that "data from the U.S. Census Bureau and the Department of Labor have shown that by the beginning of the next century, 60 percent of the new jobs will require skills possessed by only 20 percent of the young people entering the labor market." Unless we improve the education our children receive, they will not be adequately prepared to compete with their international peers in a global economy.

An additional realm of society that is heavily influenced by the development of science and technology is that of public policy. Today and in the future, lawmakers and their constituents are faced with complex issues created by our technological success. Genetically-modified foods, clean air regulations, global warming, privacy concerns surrounding our genetic information, cloning, and Y2K are all issues which—as a Nation—we must confront. If our citizens do not have the educational background to understand these relevant questions or similar ones and their debatable answers, it will be impossible for them to make informed decisions about how they wish the country to proceed. We must arm all students with the knowledge and skills to interpret scientific information so that as adults they will be prepared to intelligently participate in policy decisions that affect their world.

Before we hear from our witnesses who will elaborate on the reasons why math and science education are so important, I would like to make one last point. This hearing is not intended to provide us with answers but, rather, I hope that this hearing will stimulate questions that we should ask as we seek solutions. This is the first hearing and we want it to set the tone for the rest of the hearings. We must ensure that through our education system, we instill children with the motivation and desire to obtain the fundamental skills and knowledge to thrive in a technology-saturated future in terms of their occupations and in their personal lives as consumers and voters.

Let me add one other point just to reiterate something I have said earlier because this is something that many do not understand—and I will broaden it beyond math and science. Teaching students art, music, math and science develops the intellect in a way that aids in learning reading and other skills and other subject matters. It all goes together in one big package and I am afraid far too many people in the United States realize that important correlation and believe that if we put reading first, all of our problems will be solved. It is not that simple. We have to look at the entire picture.

I look forward to receiving the testimony of our distinguished panel as we begin this very important process.

Chairman EHLERS. And I will now recognize the gentleman from California, Ranking Member of the full Committee, Mr. Brown.

Mr. BROWN. Thank you very much, Mr. Chairman. I will try and be as brief as possible.

First, let me commend both Chairman Sensenbrenner and you and Ms. Johnson for undertaking the task of conducting these hearings. I believe them to be extremely important.

Secondly, following up on your comments about the relationships between reading and math, I would point out that the earliest known schools—which go back about 8,000 years—were the Sumarian scribo schools in which one learned to write in order to do arithmetic—in other words, to keep track of land, possessions, and to count the number of sheep that they owned and keep a record of them and that sort of thing. They were intermingled from the beginning and, of course, the earliest institutions of higher education, which were probably those originated by Plato and Aristotle—their basic curriculum was mathematics and science, generally astronomy in the case of these ancients.

So, what we are doing is continuing in a process which is almost entwined with the human culture and we need to recognize the importance of it from that historical standpoint as well as from its importance in the kind of modern, industrial culture that we have. And having recognized it, we should try to make it exciting and this is what we have apparently failed to do in connection with math and science at the earlier years—middle schools and high schools. So, if you would concentrate on how to make it exciting, you would be making a great contribution.

Thank you very much.

Chairman EHLERS. Thank you, Mr. Brown. I appreciate your historical insight on——

Mr. BROWN. I was there. [Laughter.]

Chairman EHLERS. I was just going to say that it was before my time. [Laughter.]

But that was interesting. I wasn't aware of that.

The remaining members of the Committee may submit their statements for the record and, without objection, they will be entered into the record.

It is a policy of the Science Committee to swear in all its witnesses and I ask the members of the panel to rise and raise their right hand.

Do you solemnly swear or affirm that the testimony you are about to give is the truth, the whole truth and nothing but the truth so help you God?

Dr. RUBIN. I do.

Dr. BYBEE. I do.

Dr. FERRINI-MUNDY. I do.

Ms. KASLOW. I do.

Dr. MALCOM. I do.

Mr. HARRISON. I do.

Chairman EHLERS. Let the record show that all witnesses answered in the affirmative and we will now go to the introduction of the witnesses. I will introduce them all at the same time, sequentially, and then we will ask you to speak in that same sequence. I would also—for those of you who may be new to the process—I recognize several veterans here—but for those who are new to the process, the standard rules of the Committee are that each person gets 5 minutes to make an opening statement and then the members have the opportunity to ask questions, 5 minutes each, and if necessary we will go to a second round of questions. So, even if you can't say everything you want to say during your initial 5 minutes, you may be able to amplify upon it during your question period.

The first witness to the far left is Dr. Vera Rubin, a Member of the National Science Board and a very well-known person who has made major contributions in a lot of different areas. Dr. Rodger Bybee and Dr. Joan Ferrini-Mundy—may I just call you Joan Mundy?

Dr. FERRINI-MUNDY. Yes.

Chairman EHLERS. Okay, I am more familiar with you that way—are Executive Director and Associate Executive Director respectively in the Center for Science, Math, and Engineering Education. We also have Ms. Amy Kaslow—did I pronounce that correctly?

Ms. KASLOW. Kaslow.

Chairman EHLERS. Kaslow, okay—Senior Fellow of the Council on Competitiveness. Then we have someone who has made her mark in a number of areas, particularly in PCASTs, and that is Dr. Shirley Malcom, Director of Education and Human Resources at the American Association for the Advancement of Science. And, finally, Mr. John E. Harrison, Co-Founder and Chief Executive Officer of Ecutel—is that pronounced correctly?

Mr. HARRISON. Yes.

Chairman EHLERS. Ecutel.

Thank you all for coming. We appreciate you taking the time to be here. We look forward to hearing your witness and, as I mentioned earlier, this is an extremely important panel and hearing because this is going to set the tone for where we go from here. We are really seeking direction from you as to what areas we should concentrate on as we consider how we may possibly improve math and science education in the United States and we thank you for coming.

We will begin with Dr. Rubin.

TESTIMONY OF VERA RUBIN, MEMBER, NATIONAL SCIENCE BOARD; ACCOMPANIED BY RODGER BYBEE, EXECUTIVE DIRECTOR, CENTER FOR SCIENCE, MATH, AND ENGINEERING EDUCATION; JOAN FERRINI-MUNDY, ASSOCIATE EXECUTIVE DIRECTOR, CENTER FOR SCIENCE, MATH, AND ENGINEERING EDUCATION; AMY KASLOW, SENIOR FELLOW, COUNCIL ON COMPETITIVENESS; SHIRLEY MALCOM, DIRECTOR, EDUCATION AND HUMAN RESOURCES, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; JOHN HARRISON, CO-FOUNDER, CHIEF EXECUTIVE OFFICER, ECUTEL

TESTIMONY OF VERA RUBIN

Dr. RUBIN. Mr. Chairman, Ranking Member Brown, and members of the Committee, I appreciate the opportunity to testify before you. I am Dr. Vera Rubin, member of the National Science Board and an astronomer at the Carnegie Institution of Washington.

My appearance today grows out of a National Science Board report, released 2 weeks ago, entitled "Preparing Our Children: Math and Science Education in the National Interest." With your permission, I would like to submit a copy of this report for the record.

The report is the result of our year-long review to study the disturbing results of the Third International Mathematics and Science Study, TIMSS. The Board believes that it is both imperative and possible to develop national strategies to improve K–12 teaching and learning of math and science. As part of those strategies, the science and engineering communities represent a key resource for local schools, teachers, and students. They conserve the national interest while respecting local responsibility for education.

Today's high rate of mobility makes local schools a de facto national resource for learning. One in three students changes schools more than once between grades one and eight. Such mobility dramatizes the need for coordination of content and resources. Yet, we all know that improving student achievement in 15,000 school districts will not be easy. The Nation depends on a strong competitive workforce and citizens equipped to function in a complex world. This is not just a health of science issue; rather, it affects everyone's chances.

The National Science Board report focuses on issues familiar to this Committee: what to do about each issue and how Federal resources can support local action. I would like to comment briefly on three areas: instructional materials, teacher preparation, and college admissions.

Instructional materials. According to the TIMSS results, U.S. students are not taught what they need to learn. Textbooks, teachers, and the structure of the school day do not promote in-depth learning. Most U.S. high school students take no advanced science—only one-fourth enroll in physics, one-half in chemistry. Curricula and general science textbooks in U.S. high schools lack coherence and cover too many subjects. A consensus on content for each grade level is needed with instructional methods that promote thinking and problem-solving and the creative use of technology. We must challenge our students.

Teacher preparation. One in four teachers is teaching "out of field." Only 28 States require prospective teachers to pass examinations in the subject areas they plan to teach. Only 13 test them on their teaching skills. Widely shared standards in teacher preparation, licensing, and professional development would help. Future teacher preparation is even more critical. The community partners of schools—higher education, businesses, and industry—share an obligation to raise the bar.

College admissions. Quality teaching and learning of math and science illuminates the path to college and the workplace. Data on 1982 high school graduates show that the quality of the high school courses taken is a better predictor of getting a college degree than a high school grade point average or test scores. Nevertheless, test scores tend to dominate admission procedures. High schools and colleges should increase the congruence between high school graduation requirements and undergraduate performance demands. We need a more seamless, K–16 system.

Underlying these areas is research. Questions such as which tests should be used, how children learn, invite research-based answers. The National Science Board sees research as a necessary condition for improved student achievement in mathematics and science, and other subjects as well. Such research is best supported at a national level and in a global context. Collaboration by NSF and the Department of Education should spearhead the Federal contributions to education and research.

In conclusion, Mr. Chairman, we must develop a greater consensus on the content of K–16 teaching and learning. Higher education must work to strengthen elementary and secondary education, not just wait to inherit its deficiencies. If we fail our teachers, we fail our children. The power of standards and accountability is that all students can be held to the same high standard of performance. In 1999, national strategies for excellence in education are a national imperative.

Thank you very much.

Chairman EHLERS. Thank you for your testimony and I would just observe that Dr. Kelly, who chairs the National Science Board, has also made it clear to me that a very high priority of the National Science Board at this time is precisely what we are talking about today—and that is math and science education at all levels. So, I look forward to working with you and the National Science Board on this problem.

Dr. RUBIN. Thank you very much.

Chairman EHLERS. Thank you.

Dr. Bybee.

TESTIMONY OF RODGER BYBEE

Dr. BYBEE. Mr. Chairman, members of the Committee, thank you for this opportunity to discuss one aspect of science education.

The full benefit of a science education requires that students learn both the concepts and principles of science and the abilities of scientific inquiry. These are two sides of the science educational coin and today I wish to discuss one side of that coin—primarily, the inquiry abilities. I wish to also emphasize that this isn't an "either/or" proposition. Students need to learn the basic concepts of science, they need to develop the abilities of inquiry. I am going to discuss the abilities of inquiry because that is one dimension of many students' science education that we are not attending to and developing as wholly and as adequately as we should.

Although there are numerous lists and titles—such as "Scientific Methods," "The Processes of Science," "Inquiry," "Problem-Solving," and so on—I will describe some general intellectual skills grounded easily and clearly in the sciences but I have specifically taken the science category out of these skills.

The justification for these skills, as Mr. Ehlers pointed out at the beginning, is that they may apply in other areas to help students learn other disciplines—such as history, language arts, and so on. They are also an early and clear preparation for the work of a scientist. As I go through the list, I hope you will detect that they are also important skills for individuals entering the workplace and, finally, for individuals operating and conducting themselves as citizens.

The list. Identify and questions that guide an investigation—I would note that this hearing began with the proposition, this is a question, we are asking questions, we want to see where the questions would take us, and so on. Designing and conducting an investigation. Gathering and analyzing data. Developing descriptions, explanations and predictions using evidence. Thinking critically and logically to establish a relationship between evidence and an explanation. Recognizing and analyzing alternative explanations and predictions. Responding critically and appropriately to various explanations, primarily weak explanations—for example, an explanation that confuses, correlates, and then causations. Communicating procedures and explanations.

The benefits of this list—of students actually developing this list, I think, on the face of it would be helpful to students in other courses as they pursue their K–12 career and to individuals who are going on to higher education, to the workforce, and so on. The implications that this general list would transfer to other areas. If the abilities that I described are learned in some depth that in other areas, such as history, that there is a clear and explicit expectation that the student will apply those abilities in the respective domains and that there is a rather coherent and consistent use—attempt to develop those abilities within one's educational career.

What should we do? What are some possible recommendations? I will start with what may seem self-evident but, in the case of developing the abilities that I described, isn't always applied. The self-evident statement: students learn what they are taught. If you want students to develop the intellectual abilities of scientific inquiry as general intellectual skills, then we will have to teach those abilities, not assume that they are learned in some other context in some other format. For example, many, many textbooks on science introduce the scientific method in the early part of the textbook and proceed for the rest of the textbook to outline the concepts and principles of science without ever really developing the abilities that I have just described.

Students will have to be involved in those activities through programs that are commonly referred to as "hands-on" or "minds-on" or "discovery-oriented" instructional materials. We will have to take their studies to a deeper and richer level than just assuming, for example, if the students observed something today that we can check observation off the list and move on. Notice that there is a deeper and richer value thinking critically and logically, for example, about evidence and so on.

What do we need? We need curriculum materials that emphasize the abilities of scientific inquiry that emphasize those abilities—not as a means to learn other concepts and principles of science, but as a primary emphasis of at least a part of the student's science education experience. We will also benefit from having curriculum materials that model the abilities of inquiry in other disciplines, such as history, geography, language arts, and so on.

Primarily, I would say, our greatest resource to achieve a greater development of these abilities would be the teachers who understand and are able to implement the abilities that I have described. We will also need assessments that evaluate the attainment of those abilities that are consistent with the goal. And, very importantly, we will need public support for teaching science as inquiry as a valued goal of science education.

Thank you.

Chairman EHLERS. Thank you very much and I just noticed that the timer clock has been shuffled off to the corner there. If you want to turn it around so that it is facing you, you can actually see the time and the lights flash and all that sort of thing.

Thank you for your testimony and we will now turn to Dr. Mundy.

TESTIMONY OF JOAN FERRINI-MUNDY

Dr. FERRINI-MUNDY. Thank you, Mr. Chairman and members of the Committee. I appreciate the opportunity to speak with you today. I am a mathematics education person at the National Research Council.

And I would like to build upon Dr. Bybee's points concerning both the content and processes—in this case, in mathematics education—and try to make the case that these content and process aspects of mathematics serve students well in academic areas outside of mathematics. And, in fact, I propose that the processes and ways of thinking that are foundational to today's outlooks in mathematics education are really fundamental to all areas of the school curriculum.

Let me take up content first. Most efforts at mathematics curriculum and mathematics education today include, for example, attention to data analysis, statistics, and probability. They call for students to learn to do the following kinds of things—and they are very similar to the list that we heard from Dr. Bybee in science: to pose questions; to collect, organize and represent data to answer those questions; to interpret data; and to develop and evaluate inferences and predictions.

It is in mathematics classrooms where students learn to read tables and charts, judge whether a survey is reliable, understand whether a finding of multiple occurrences of an event is different than what might happen by chance. These tables, charts, surveys and findings need to be about something. They can be about demographics, about public views, or about clusters of cancer occurrences, the point being that the data gathering and representational tools now so central in the social sciences are learned in the mathematics curriculum.

As aspects of the world around us are described quantitatively and students learn about the spread of epidemics, the way the economy works, or factors that determine social trends in their social studies curriculum, fundamental mathematical knowledge is being drawn upon. Trends and changes are represented with graphs that are addressed in the math curriculum.

Particular mathematical topics are also important. In understanding social studies topics as diverse as crime rates, population density, metropolitan growth or availability of resources, students need to understand rate and ratio and to reason proportionately. And these are mainstays of the middle grades mathematics curriculum.

So, I have focused on a few content areas that I believe are central, not just in mathematics but in all areas of the curriculum. I would now like to turn to process.

Even more compelling, I think, than the notion that the content of K–12 math education is central to other school disciplines, I would like to make a case that the notion of processes of mathematics are actually processes of great use in other domains. Consider the following list which is typical of many national and State standard framework documents: problem-solving; reasoning and proof; connections; communications; and representation. Had I not said proof, that list might as well have applied to many areas of the curriculum and not particularly mathematics.

I contend that the ways of thinking that are at the core of these views of mathematics education are fundamental. It is in science and math classrooms that students can learn to reason, to communicate parsimoniously and unambiguously, to assess claims, detect fallacies, evaluate risks, and analyze evidence. These might certainly qualify as the skills of sophisticated reasoning and practice that many view as critical for the workforce.

Consider for a moment the kinds of understanding and thinking that might be involved in evaluating risks—say, risks of getting cancer or being delayed in travel because of weather. If one unpacks the notion of evaluating risks, it might be clear that knowing the difference between correlation and causation and assumption and a conclusion, or a representative and a biased sample, or using evidence versus opinion are all important and these are ways of thinking, again, that I would emphasize are critical in the mathematics curriculum.

In preparation for this discussion, I looked at a seventh grade history textbook that was in my house and found a section titled, "Making Generalizations From Maps." And I looked closely and the mathematical work involved in this assignment was quite considerable. There was a map including several different colors that were representing different time periods. The notion of assessing this visual information and making judgements and inferences is a fundamentally mathematical kind of activity.

In closing, I would like to make two points about where I think Federal programs can be of assistance in this important area and both have to do with research. I feel that we need basic research about student learning in mathematics and science and as it might relate to these issues of transfer that we have been discussing to other areas of the school curriculum. This research needs to focus on particular curricular approaches to mathematics and science teaching and also teaching approaches with a focus on how student growth in these reasoning and process areas can grow over time.

Secondly, I believe that we need research about teacher learning and development that can guide programs for teachers. In particular, how do teachers learn to help students learn, to emphasize these kinds of processes that I have spoken about here.

Thank you very much.

Chairman EHLERS. Thank you. I appreciate your comments and let me just add I noticed a large number of students in the audience and I am certainly happy to see you here and welcome you to this hearing. We are talking about how to improve math science education in the United States and what we are deciding here may not help you right now——

[Laughter.]

Chairman EHLERS [continuing]. But we hope it will certainly help your children. Thank you for your interest and for attending.

Next, Ms. Amy Kaslow, Senior Fellow, Council on Competitiveness.

TESTIMONY OF AMY KASLOW

Ms. KASLOW. Thank you.

For the past several years, the Council on Competitiveness has focused on best practices and workforce preparedness through an extraordinary lens. Strong participation from the business, labor, and education communities have helped us to develop our views. My remarks draw on a project that I directed under the co-chairmanship of Richard Notabart, the Chairman of AmeriTech Corporation, George Becker, President of the United Steelworkers of America, and Hal Ravishe, President of Stephens Institute of Technology.

We have studied what happens when the K–12 system fails to deliver on the basics. We know that workers at all levels suffer and that every industry is hurt. So, it would be a mistake for the Committee to regard this solely as a socio-economic problem or one that is sector-specific or one that is simply about a subset of the U.S. workforce. It is a nationwide dilemma but not something you are going to read about in the headlines.

In fact, never before has the appearance of working America been so deceiving. Payrolls have hit record highs and the unemployment rate is the lowest it's been in decades. But the reality behind the numbers is very troubling.

An acute skill shortage in every part of the country threatens the foundation of American competitiveness. While debate rages on about the K–12 dilemma, the inadequacies of American schooling are inescapable in the American workplace, where too few people have learned how to learn.

By that I mean too many new graduates, would-be workers, and existing employees cannot read or do simple math—two essentials for adapting to new tasks and meeting market demands. Remedial education has become the norm, not the exception, and that is before any training can occur.

Widening skills and wage gaps among U.S. workers have taken on more complicated meanings and there is a premium on new entrants who have the skills to land positions. There is an equally high value put on incumbent workers who are savvy enough to upgrade their skills for ever-changing demands. The flip side, of course, is the penalty for those who fail to measure up.

In our 2-year search for best practices that help bridge these gaps, we drew upon experts and practitioners in the training field, and we hosted many meetings in Washington, where decisions about workforce training once originated. But recognizing that problems and solutions are locally based, our research team moved around and covered a wide swath of the country.

We listened to people. We met with CEOs and managers from the modest start-up firm to the multinational, who typically reject the vast majority of job applicants—upward of 80 percent—because they fail to meet the most rudimentary standards. We logged many hours on the factory floor meeting with organized labor and nonunion workers, some of whom shared their fears of further training and others their successes in retooling their skills. We sought out the most cutting edge educators, including community colleges, vocational training centers, and corporate community universities where workforce preparedness is big business. We captured some of the most dynamic work at municipal offices where professionals are dedicated to matching skills with employer needs.

Our findings are by no means exhaustive but they are strongly indicative of the depth and the scope of a pressing, national concern. We fully appreciate the need for strong analysis backed by sound data but we tried to put a human face on a challenge that is urgent and too often viewed as an abstraction. The problems and potential solutions are not limited to any particular place or time, nor are they restricted to one level of the workforce. The issues are very real right across the spectrum.

In the Midwest, for example, business has been booming and skilled labor is nowhere to be found. A major employer in Milwaukee, the automation firm Allen-Bradley, is working against time because, within 10 years, 80 percent of its employees will retire. The greying of the national workforce has produced a massive requirement to replace a generation of skilled wage-earners that will reach retirement by 2005. To avoid their own contraction, companies like Allen-Bradley have been scouring both local and distant schools to find qualified new entrants. This fixation on meeting current labor needs has become management's most absorbing responsibility.

In part of the Sun Belt, populations are growing at staggering rates. US West Communications has been unable to meet service demands in Arizona, Colorado, and Nevada, where many newly-built homes have no access to telephones. With an infrastructure originally designed to meet the needs of a small, rural population, US West cannot keep pace with today's construction rate. Companies like US West, ever-more technologically-advanced, are hard-pressed to train, hire, and retain a whole range of workers in one of the Nation's most competitive industries.

Nowhere is the bidding war for skilled technicians hotter than in California's Silicon Valley where some 80 percent of the jobs require specialized learning and basic technical knowledge. Skills are particularly prized because of the constant churning among existing workers who jump to new job opportunities. Local community colleges are among the best equipped schools to tailor training programs needed to transition workers from one job to the next. Whether the courses are offered on-site, at corporate headquarters and plants, offered at the school campus, or available on-line, the learning process is geared toward immediate and practical application in the workplace. The most progressive and the most successful firms use this "just-in-time" learning.

The scramble for workers is just as intense in the entertainment industry where the skills requirements are less rigorous than the tech industry but just as tough to come by. Service sectors in areas like Orlando, Florida must satisfy massive and immediate hiring needs. Rapid turnover only exacerbates problems for Walt Disney World Company and Universal Studios, the area's two major employers drawing from the same shrinking pool of workers. Like other areas across the country, Orlando's supplier firms and other small businesses that service or have grown as a result of the big companies' expansion are losing the fight for the very same workers.

Complicating these developments are a set of trends that will only intensify in every sector of the economy. Information technology is a defining feature of the American workplace, adding computer literacy to the list of basic skill requirements and generating even more demand for workers. Global competition is not just a challenge from overseas. It is right in our backyard. Well-trained foreign workers abroad lure increasing numbers of American companies to set up shop outside U.S. borders, but foreign workers who are "imported" to the United States underscore just how essential skills are to worker marketability, and they reveal how the ill-equipped American worker is at risk of being cast aside for the international with "know-how." And, over the next five years, welfare reform will move many millions of mostly unskilled Americans from public assistance to entry-level jobs. Without adequate preparation, they will only add to the ranks of the unemployable.

In sum, you asked us for a brief outline of problem. The Council's report, "Winning the Skills Race," which I would like to submit for the record, draws on a much richer set of examples than I was able to mention here. But more to the point, we have documented innovative collaborative efforts between employers, workers, educators and government, that have boosted the skills, and ultimately, the income of American workers. When you are ready to consider solutions, we strongly recommend that you take a look at these collaborations. They very clearly lead by example. Thank you.

Chairman EHLERS. Thank you for your testimony. Without objection, the Council on Competitiveness report, which you referred to, will be entered into the record.

Ms. KASLOW. Thank you.

Chairman EHLERS. Dr. Malcom, welcome.

TESTIMONY OF SHIRLEY MALCOM

Dr. MALCOM. Thank you very much. Science, math and technology is not just for scientists, mathematicians and engineers. As our business, service, regulatory, transportation and other systems have become more technically based and scientifically connected, the need for advanced scientific quantitative and technical skills has diffused out into many other areas of the work force. When these systems don't work well, they affect all of us. Science and technology-based industries are supported by technicians, but they are also supported by sales, legal, and marketing forces, all of whom must understand the products being developed. Our lawyers, judges, pilots, air traffic controllers, legislators, and business people increasingly need the knowledge, concepts, and ideas of science, math, engineering, and technology as well. So do the service men and women who must defend our country as they use and maintain tanks, planes, ships, trucks, and weapons, or detect the presence of biological and chemical toxins. Those who monitor the safety of our water supply and our food, who track infectious diseases, who keep us healthy, who fill our prescriptions, who maintain our environment, who care for us in hospitals and nursing homes all need a much higher level of knowledge, skills, and ideas in these areas.

There are few jobs and professions that have been left untouched by the scientific and technological revolution in which we find ourselves. Yet we send too many into this revolution unarmed, lacking the skills, knowledge, and understanding they need to do the Nation's work to earn a living now and for the long-term.

But it isn't just about making a living that we want to focus on, it is about just plain living. About understanding the treatment options for ourselves, for our parents, and for our children. About realizing if the temperature is below 32 degrees Fahrenheit, the moisture on the road is likely to be ice, and we probably shouldn't speed. About recognizing what household cleaning products should not be mixed. About understanding that greater stopping distances are needed at greater speeds. That fully-loaded trucks don't handle like those with empty trailers. It is about being able to interpret the drug information profile that accompanies the prescription. It is about safe food handling. We can do all we want to protect food safety from the field to the grocer, but not from the grocer to the table. That can only be the consumer's responsibility and the consumer's actions.

The mathematics that is involved in the dilution of an herbicide or fungicide or pesticide that we use around our home, where unsafe handling can be disastrous, or even just the knowledge that is needed in terms of purchasing wallpaper. The headlines in today's newspaper scream out about the horrible tragedy of the train crash in Illinois. It is not yet clear where the cause lies, whether there was an error in judgement of a driver of a fully-loaded vehicle trying to outrun a train moving at 80 miles per hour, or the failure of a signal or gate mechanism. At some point, the deliberations are going to become technical. The review of the black boxes to reconstruct the conditions of the train, the review of the centers that are associated with the gate and the lights.

We regularly allude to the idea of science, math, engineering, and technology for citizenship, but I think we have to make this notion concrete to really understand what the stakes are. How does the public respond to issues of nuclear power versus cold generated power, or genetically modified plants or animals? How do we have discussions about personal or family health choices without fundamental understanding of human biology? How do we manage safely the use of antibiotics to promote health and growth with livestock and poultry, and at the same time, prevent the development of antibiotic-resistant strains of bacteria from threatening human health? How do we handle threats, real or imagined, to our children from an Internet that they can navigate and we can't? How can we exercise our responsibilities as voters or members of a jury? What happens when DNA evidence is presented and our jurors have no clue about how to interpret competing arguments of scientific experts?

These concerns strike at the heart of our family responsibilities and our democracy. I fear that we are rapidly being led to a legal system that actually depends on people being uninterested, uneducated, or confused about science-based evidence a frightening threat to our system of laws. While we rebuild our education systems into ones that regularly provide scientific and technological literacy to young people as future voters, we are left with the challenge of providing this for the rest of us.

The overwhelming majority of the U.S. population are beyond the direct instructional reach of our schools and colleges, and yet they need the same information. We are going to have to depend on our informal sector to do a much better job than it is currently doing. We are going to have to rely on the media working with scientists, engineers, and technologists and mathematicians to really bring the knowledge of these areas to life for most people. What is at stake? Not only our livelihoods, but our lives.

Chairman EHLERS. Thank you very much. I appreciate that. And to wrap it up, Mr. Harrison.

TESTIMONY OF JOHN E. HARRISON

Mr. HARRISON. Thank you, Mr. Chairman, and members of the Committee. As you said, I am John Harrison, co-founder of Ecutel. I would like to thank you for this opportunity to testify.

This issue of math and science education in the United States is one that directly impacts me every day as CEO of Ecutel. We are a small technology firm that is constantly recruiting scientists to make our products and to create new ones. We are also dependent upon a technically savvy workforce to buy our products. As we all know, innovation and useful technologies are the fuel of our current and previous economic growth. If this boom is going to continue, and companies like Ecutel are going to succeed, then math and science education needs to be mandatory in all grades from K through 12.

U.S. colleges are some of the most technologically innovative in the world. In fact, many foreign nationals attend U.S. graduate programs to further their education. However, few U.S. students have the fundamental knowledge from elementary and high school levels to take advantage of these institutions. Ironically, these levels pave the way for a knowledgeable workforce and stimulate the minds of future scientists to make innovative products.

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I believe if I tell you a little bit about Ecutel, you will see how and why all U.S. information technology firms equally suffer from a lack of computer science and electrical engineers that are of U.S. citizenship. Dzung Tran and I formed Ecutel three years ago. We had a great idea to create a software product that would support the many requirements of the increasingly mobile and data hungry workforce. That product is the Viatores Mobile VPN. It is based on components of the Next Generation Internet. Ecutel took these concepts and made them work in today's information systems. This is no small task. We had to spend many hours of design before we felt comfortable leaving our previous jobs to form Ecutel.

But designing is not enough. We needed sophisticated engineers that could make it a software rather than a hardware product. That is so people wouldn't have to carry around a lot of extra equipment as they roam the Internet. Internet roaming is similar in concept to cell phone roaming. Furthermore, we needed engineers that could incorporate encryption and decryption methods so the data is not compromised as it flows through the Internet. We received 630 resumes in those first few months. Of those that we deemed qualified, none were U.S. citizens.

This had a much greater impact on us than we ever thought it would. First, in 1998, we spent over $80,000 on immigration legal fees. That is a lot of money for a small firm. Two, we could not bid on contracts that required security clearances because we didn't have any American engineers that could qualify for a clearance. Three, we couldn't work in some areas of encryption/decryption, which is pretty necessary for secure communications. Four, if foreign travel were required, our engineers could only leave the United States once unless they had a multi-entry visa which is costly and time consuming.

Now if 20 years ago we had force-fed math and science education into the minds of U.S. kids, Ecutel could have used that $80,000 to hire another engineer and to make more innovative products, and to more aggressively market Viatores. Increased marketing would have given us more revenue, subsequently providing us more funds, which then could be used to make more innovative products once again, which ironically requires more engineers. We would also have a much more technically savvy workforce that could adapt more quickly to these innovations. This is a never-ending cycle in the world of information technology.

In 1998, the U.S. had to increase its number of H–1 visas from 65,000 to I believe 105,000. The reason to me is clear: U.S. innovation was out-pacing its ability to innovate from within. In the case of Ecutel, we were able to circumvent this problem, the problem of a lack of American engineers, by working with other companies to minimize the amount of development that was required. This is by no means a sound solution. We do not want to minimize development because that reduces the potential for innovation. It doesn't matter if you are the size of Microsoft or Ecutel with 15 employees. They both suffer from the same problem. It is companies like Ecutel that fuel this economy through their innovations. Large companies know this. That is why they are constantly buying smaller firms, so that they can stay ahead of the innovation curve.

I don't want to mislead you. I wouldn't trade any of Ecutel's engineers. In fact, I deeply respect their tenacity and their intelligence. I believe they offer more than technical know-how. They offer a view, a cultural view on areas of the world in which Ecutel will eventually expand if it is going to succeed in this global economy. But if we can't figure out a way to make it easier for small technology firms to maintain a qualified engineering staff at a low cost, then innovation suffers, and so does our economy.

As co-founders and partners in a small firm in a high tech industry, Mr. Chairman and members of the Committee, Dzung Tran and I have concluded that two things need to occur in the very near future. One, math and science education needs to be in a child's everyday activity so it stimulates their intellect and becomes second nature to them. Even if they don't want to become scientists, we still need them as a technically savvy workforce so that they can make use of these innovations. Two, until our kids are ramped up on technology, let's make immigration laws easier so the necessary technical skills remain in the hands of U.S. companies so that we stay on top of the world's innovation curve.

This concludes my testimony. Again, I would like to thank you for this opportunity. I would also like to say "hi" to St. George's grade school, St. Mary's grade school, and PDS, who are all watching this in Memphis, Tennessee over the Internet. I would also like to invite everybody over to Ecutel to see what I am talking about.

Chairman EHLERS. Thank you very much. We thank the students for their interest in watching. We are very, very pleased on the Science Committee that we are now able to use the most advanced hearing room in the Congress, and that we are able to webcast all of the hearings that we hold. So we hope they will continue to watch.

The point you make, incidently, about the difficulty of getting American engineers is not only in industry. If you look at the graduate schools of this country, over half of the graduate students in science and engineering are from other nations as well. So we are simply either not producing the individuals who are capable of entering grad schools, or filling the workforce, or they are choosing on their own volition not to enter that. If they aren't, if they are making that choice, I would like to know why and what appeals to them more about other fields.

Just a few details. All the written testimony that has been submitted—I noticed many of you summarized it with oral testimony. One of the witnesses still has a microphone on. That is why we are getting feedback, so if you could each check yours and turn it off. Thank you. Much better. All the written testimony that you submitted will be entered into the record, without objection. So even if you had to summarize it in your oral testimony, everything you wrote down will go in the record.

Another comment. We are in session on the Floor. We anticipate votes at any time. If you hear the buzzer go off, I will apologize, but we have no choice but to go and vote, and we will have to delay proceedings.

We will now begin the questioning. As I mentioned earlier, it will be five minutes for each member for questions and answers. If there is a request for more questions, then we will have a second round, time permitting.

First of all, and I will comment as well as question, but Dr. Rubin, I noticed your emphasis on the number of students switching schools. I had observed that of course in my own experience. Although I taught in higher education, I was interested in elementary school science, so I got involved with elementary schools and found it appalling. A number of schools I went to, they had substantial numbers of students who switched schools four times during one year. It seems to me that we have to address that problem, as you pointed out. Can you give me some idea of what your preliminary thinking is on how we address that?

Dr. RUBIN. I think that the Board feels that it is really mandatory that we have some national standards so that when students transfer from one school to the next, they won't be one year behind or one year ahead. At the present time with so many individual school districts, in general the children that transfer from one school to the next really do get lost. That is a severe interruption in their education. With the extent of the United States, with the extent of mobility, it is only through some kind of national understanding, some consensus, and the Board in its report calls upon all of the stakeholders, parents, school boards, school personnel, universities that train teachers, in a community to see how their educational processes can fit into some national consensus.

I think this is an area that the Board is very interested in. The report came out of the discussions around the Board about a year ago, where we felt that the TIMSS report was one of the most important things we could consider.

Chairman EHLERS. Thank you. Isn't it true it's not just a matter of setting standards, however you define that term or reaching a national consensus on what should be taught, but also when it should be taught? In other words, a sequence.

Dr. RUBIN. Yes. Yes.

Chairman EHLERS. Is equally important.

Dr. RUBIN. By some consensus, we mean in each grade, at each grade level there should be some understanding of what a student in that grade level will know in math and science.

Chairman EHLERS. And Dr. Bybee and Dr. Mundy, we had talked earlier about the need, and you talked about it also, how studying math and science reinforces studying of reading, history, many different subjects. But you made an emphasis of how math and science can reinforce each other. I forget which of you made that point. I am interested in how you would see that applied. Do you think it would happen just by virtue of teaching a good course in math and a good course in science? Or do you think there should be some attempt to correlate the teaching of mathematics or the teaching of science that would be a direct application of the mathematics that is being taught? Do you have any thoughts on that?

Dr. BYBEE. We haven't coordinated our responses. It will be interesting to hear. I would suggest that if you take a grade level, for example, or a unit, that one could organize a sequence of instruction that investigated a scientific topic of some sort, and at the same time, when mathematical ideas, graphing that Joan mentioned, for example, would come up, that the same topic would be addressed in the math classroom. So there is a kind of parallel structure and organization of content. Still honoring the mathematics content, and still honoring the science content of the lessons.

Chairman EHLERS. Yes. Joan?

Dr. FERRINI-MUNDY. I would just add that I think in the elementary grades, in many cases where the same teacher is teaching mathematics and science, that kind of coordination is more natural and should be facilitated in the way Rodger describes. I think in the secondary grades, we have a larger challenge in trying to coordinate mathematics and science education. That needs work.

Chairman EHLERS. Thank you. By the way, it is very important to correlate math with reality in some way. I can give a little example. As many of you know, I am the first physicist ever elected to the Congress. After only five years, we have a second physicist elected. Being a physicist, I did an immediate calculation. That is, we doubled in five years. [Laughter.]

Using a doubling time of five years, I calculated that by the year 2035, all of the Members of Congress will be physicists. Now you may note that there are a few assumptions in that theory. [Laughter.]

Even though it would be a better world, it is not likely to happen.

My time has expired. So I recognize Congresswoman Johnson.

Ms. EDDIE BERNICE JOHNSON of Texas. Thank you, Mr. Chairman. I was the first registered nurse to be elected to Congress. In five years, we doubled. [Laughter.]

Let me thank the panel. My frustration level goes high when I listen to this testimony, but the frustration is not getting anywhere because I don't know where to go. Last session, I did introduce some legislation that was called the Math and Science Proficiency Partnership Act, which will target urban areas. I am restructuring it this year to also include rural areas, where the students in their schools often lack the resources that more affluent areas have. So the grants through the National Science Foundation, which is an extension of the systemic program, urban systemic program, will be awarded to school-business partnerships to train math and science teachers, and to train math and science students.

As an active partner with the schools, businesses will be encouraged to set up on-site internships and mentoring for students to establish college scholarship programs, as well as to donate computer software and hardware. I am looking for cosponsors, but that is an effort that I think will help.

In my area, I am very familiar with the H–1B, because we really had to move that forth because our businesses were very, very concerned about not having the talent available, especially to go into year 2000. We continue to have that problem. One of our small businesses came here visiting when we were debating the H-1B legislation, and said "I have a workforce of 85, but I have 80 vacancies." That is impressive.

We are finding more and more that in areas around the country the unemployment rate is way down, but it is still high for innercity, minority youth. These are the areas of the jobs. I am in a struggle, as most everyone is, trying to determine what we can do.

There is some attitude against national testing or benchmark testing. I don't know how we determine the level of quality without it, but I would like—I was very interested in Ms. Kaslow's testimony because she is directly from the industry, so is Mr. Harrison, who know first hand where the vacancies are, and Dr. Malcom, who made it so plain for everyday living.

You must have some ideas as to how we can move about attempting to address this. So if you will just comment a little bit further, I would appreciate it. Then I do have one question about the testimony of Mr. Bybee and Ms. Mundy on the classrooms, and suggestions as to how to apply what we know about learning science and mathematics.

So if all of you could comment on that, I would be greatly helped, a little bit more specifically than testimony.

Chairman EHLERS. Thank you. Would you respond in turn, and please try and keep your answers brief.

Dr. RUBIN. Let me say that one of the Board's positions has been that partnerships, and coming from the Science Board, our view is that scientists and universities and such organizations should partner with undergraduate colleges in training teachers with school boards.

Let me take off my Board hat and put on my Carnegie hat. The Carnegie Institution in Washington about 10 years ago introduced from its downtown headquarters at 16th and P, an inner-city Saturday science school. In 10 years—starting with children from second to fifth grade. This is a hands-on, experimental, great fun program. Many of these children are now in high school, taking physics. The initial environment was only for children who could actually walk, who lived within that area. But the program got so interesting and schools relatively nearby were really begging to get in, about five years ago, it spread to a teacher training program in the summer, funded by NSF. One hundred elementary school teachers are trained in using mathematics in their daily—mathematics and science. When the students draw with chalk, they discuss what the chalk is made of, what the paper is made of.

This year, this summer there will be a math institute for teachers for the first time. The second to fifth garde teachers really insisted that they don't know enough of the mathematics. It came from their insistence. It has taken several years to set it up, but that is starting. While you don't reach many people that way, you do, by involving the teachers, ultimately perhaps reach a large fraction of the school, elementary school population in Washington.

Chairman EHLERS. Thank you.

Dr. Bybee?

Dr. BYBEE. Very briefly, addressing the issue of classrooms and the application of what we have discussed there, I think it would be important to underscore the development—two things. The development of instructional materials that clearly embed what we know about learning, the processes of learning, what it means for young children to learn the content of science. Secondly, what it means for them to develop the abilities of science.

The second point would be to combine those instructional materials as they are implemented in school districts and schools, including urban systems, with strong professional development programs. So the teachers not only know about the instructional materials, but they have developed an understanding of the content themselves, and experiences with the instructional materials, and with the abilities of science. They should have some of those very fundamental and rudimentary abilities themselves.

Chairman EHLERS. Dr. Mundy, do you wish to add something?

Dr. FERRINI-MUNDY. Just briefly to combine the two points that we have just heard from Drs. Rubin and Bybee. That is, that teacher education and teacher learning seem critical to this ability to apply what we know in classrooms really, and that on-the-job learning for teachers needs more exploration. How can teachers be learning as they are teaching, as they are working with children, as they are trying to use curriculum materials in the classroom, both to learn more about the content of math and science, to learn more about the processes, and to learn about students learning from the context of teaching.

Chairman EHLERS. Thank you.

Ms. Kaslow?

Ms. KASLOW. K–12 is going to take a long time to fix. That is obvious to everyone here. But in the interim, there are a lot of things that can happen and actually are happening.

It is no longer a luxury for the business community to react. It is a necessity. So we have seen a lot of industry mentoring. We need to see a lot more of getting employers in the schools, literally explaining what kinds of skills they need, because there is a very practical nature to science and math application. It needs to be immediately applied.

Students need to see that this is something they can directly transfer from the books in the classroom into the workplace, and get a sense of the there-there when they graduate, and incentives, obviously, to go on for further education, whether it is vocational training, which has had a bad rap over the years, but has greatly changed in scope, or whether it's the Ph.D.

We need to get teachers in the workplace to understand what they are teaching, why they are teaching, and how they are teaching can be transferred. Of course we need to get students into internship positions.

The Council has been a strong proponent of coalition building. That is, industries, workers, worker representatives in many instances, educators, and of course government folks, municipal, largely local, municipal folks, who are designing programs that get all these parties together. Find out what is needed and apply it.

We have seen it work. We have a lot of examples of how it can be done.

Chairman EHLERS. Dr. Malcom?

Dr. MALCOM. Let me say that maybe the best thing is to keep your eye on what we will be doing over the next several years. I say that because in my bio, it basically says that I am Co-principal Investigator, along with Dr. Maxine Singer, who is President of Carnegie Institution of Washington, in an effort that we have called D.C. Acts, which is a systemic reform planning effort for the District of Columbia public schools. We plan to basically submit a full-blown proposal—the third Co–PI is Superintendent Arlene Ackerman—where we will essentially take all of that knowledge that we know about what has worked and what needs to be done with regard to professional education of teachers, with regard to the professional development activities, and what qualifies as good professional development activities, to serve as an umbrella entity for other agencies and Departments of the Federal Government, as well as for industry and higher education, to come together in a coherent way to address some of these issues.

We have gone a long way in our planning. We have some industrial partners who are already on-board, including Intel, who will be doing some training here around technology. We are putting some pieces into place so that we come out with something that is coordinated and coherent, and reflects the best research that we possibly can do. I think that this is a matter of joining in partnership among all of these people who have resources, who have knowledge, who have contacts and networks that can basically be brought to bear on very resistant problems.

The issue of professional education and professional development over the long-term is something that is going to take a long time to deal with, but we are developing plans that include scaling to every institution, every elementary, middle, junior high, and high school within the District.

We don't know what works. We have a large sense of what, of what pieces work, but not necessarily what is going to basically work to pull all the pieces together. So there is an element of research that is also, that is embedded within this, and very tough evaluations so that we can figure out what is effective and what is not.

So I would hope that we would have your support as well as your eyes and ears, watching to see how we develop over time, and if we can do together something that I just don't know that any one of us can do if we aren't working together.

Chairman EHLERS. Very well put. Thank you.

Mr. Harrison?

Mr. HARRISON. Well everybody else up here seems to be a Ph.D. in this subject area. So I am going to feel comfortable leaving my response to the realm of my own experience. It seems that the resumes I received from U.S. citizens that are attempting to be computer scientists or electrical engineers, they are just not deep enough. It is a thin veneer of understanding and a thin veneer of education. When we interview them, it is not very impressive. Ours is a very sophisticated, deep, low-down development. It stumps them.

My only recommendation would be at a very high level was to no longer make math and science an option. In elementary school, it should be in every grade. In high school, it should be advanced for everybody. Math and science for every grade. Don't give them the option.

Chairman EHLERS. Okay. That's interesting, because that is one of the recommendations we had in the report that we produced last year. Too often schools regard it as optional.

The gentlewoman's time has expired. Next we have the gentleman from Texas, Mr. Smith.

Mr. SMITH. Thank you, Mr. Chairman.

Ms. Kaslow, could I direct a couple of questions to you. On the way there, let me compliment you and the Council on Competitiveness for the great work that you have done that I am somewhat familiar with over the last couple of years. So thank you for that. It is much appreciated.

You mention in your testimony that we have an acute skills shortage. The companies that I have talked to, particularly the high-tech companies, tell me that they spend not thousands, but millions of dollars every year training individuals just to have basic skills. I think you said—defined basic skills as reading and knowledge of simple math, something along those lines. So this is a problem that is across the United States, and from which many companies suffer.

Also I read an article recently in Investors Business Daily saying that 90 percent of all future jobs in America are going to require more than a high school education. Is that something you have run across as being generally accurate as well?

Ms. KASLOW. Yes. That trend is only going to get more intense because of the computer illiteracy that we see. Also that 90 percent figure, I mean all these—you can throw around a figure easily and have nobody dispute it. But 90 percent of the applications generally are discarded by mid-sized to large corporations.

Mr. SMITH. So let's say that you agree that it is going to be 90 percent or more are going to require more than a high school education, particularly computer skills and so forth. One concern I have that I want to ask you about goes to what I consider to be an out-dated immigration policy that is having unintended consequences.

We have a policy today that you are probably familiar with, that allows about a half a million people to come to the United States who basically lack any skills and have less than a high school education or equivalent. Don't you think it would help our skills shortage and it would help our American competitiveness if we had more domestic workers and more foreign workers that had at least a high school education?

Ms. KASLOW. So you would select folks based on their—you would select folks based on their educational background or their skills?

Mr. SMITH. That would certainly be one way. I guess I am talking about wouldn't it improve our competitiveness, wouldn't it improve our workforce?

Ms. KASLOW. It probably would improve our competitiveness if we started right here with the skills standards here rather than starting to screen those coming in.

Mr. SMITH. I understand that, but my point again, to emphasize it, is that two-thirds of the future population growth of the United States is going to be due to immigration.

Ms. KASLOW. True. And it is going to be intense pressure.

Mr. SMITH. Right. So wouldn't it be helpful to have more individuals coming to this country that had some basic skills and had that high school education or equivalent?

Ms. KASLOW. It would be, but that is a politically, horribly politically loaded question.

Mr. SMITH. No, I know it's a political decision.

Ms. KASLOW. I am not going to jump into that. But I will tell you one thing. In New Mexico, which is a majority minority population——

Mr. SMITH. Right.

Ms. KASLOW. And we have just heard Dr. Malcom talk about the successes of Intel. Intel in New Mexico got involved quickly. It was looking for some place to position itself and open a plant. It found that there was great tax advantages to being in New Mexico, but one of the highest illiteracy rates in the country. You know, it didn't provide a ready pool of workers. What Intel did was transfer hardware, software, trained the teachers, et cetera.

Mr. SMITH. Let me interrupt you. I know of other companies who have done the same kind of thing.

But I want to go back to my question. Disregard the political. Just tell me what you think would be good for the American workforce, good for competitiveness, and good for providing basic skills. Don't you think the more people with a higher education level would be better?

Ms. KASLOW. In a perfect world, but I don't believe in putting up barriers just because we have a problem that we are not dealing with at home.

Mr. SMITH. No, no. Don't misunderstand me. I am not talking about barriers. I am not talking about a perfect world either. I am talking about the American workforce and competitiveness. If you think it is better to have a more educated workforce, you ought to say so and not worry—let us worry about the politics. You worry about the merits.

Ms. KASLOW. That's too dangerous.

Mr. SMITH. So even on the merits, you are not willing to say we should have a more educated workforce?

Ms. KASLOW. I think there are so many complications to that set of questions, that I would not be prepared to support that. I don't think the Council would take a position on it.

Mr. SMITH. Okay. I am not asking the Council to take a position. Let me ask my question one more time, Mr. Chairman.

Ms. KASLOW. I understand. I understand the question very well.

Mr. SMITH. Forget about the politics. Do you think that the United States would benefit from having a more educated work force? Just yes or no.

Ms. KASLOW. Of course.

Mr. SMITH. Okay.

Ms. KASLOW. Yes.

Mr. SMITH. Thank you.

Let me—do I have time for one more question, Mr. Chairman? I am on my orange light.

Chairman EHLERS. You have 15 seconds.

Mr. SMITH. Fifteen seconds. In that case, I'll pass, and wait for the next round. Thank you, Mr. Chairman.

Chairman EHLERS. The gentleman's time has expired. Next we recognize a gentleman who is always attending these hearings on education, and has a good background in it, Mr. Etheridge.

Mr. ETHERIDGE. Thank you, Mr. Chairman. Let me thank you for convening this hearing, and for the panelists for being here today. This is a very, very important subject. I want to thank you for setting it up. As the chairman indicated, this is one of the areas that I have a significant interest in, having been superintendent of schools for the State of North Carolina, before I came here, and having to work extensively with the Carnegie Foundation and a number of others.

But I read an article recently that I want to submit for the record, Mr. Chairman, if I may. Let me quickly explain.

Chairman EHLERS. Without objection, so ordered.

Mr. ETHERIDGE. Then I will ask a couple of questions outside that. It was really in the—it dealt with this whole issue that was raised a few moments ago by Mr. Harrison of the availability for people in the high-tech industry, but more importantly I think a concern for us in public schools in America, the lack of those people available for people of color, our African-American, Hispanic. There was an article in the San Francisco Chronicle in Silicon Valley, and I am not picking on Silicon Valley. It just happened to be the article. It could be in a lot of other places. Only four percent of the people employed in that industry were people of color.

My concern is as we look at America and the changing demographics in this country, as we look down the road, we have some significant changes to make. That gets me to the questions I want to ask.

Dr. Rubin, you talked about standards in math and science, which I happen to agree with. North Carolina put them in. It is very easy to deal with math because we use the TIMSS. North Carolina moved in that regard back in the late 1980s and early 1990s. We are seeing significant success at fourth and eighth grade in math and science testing.

You also talked, one of you did, I believe, about curriculum. I happen to believe that is one area that is really lacking as we look across the areas. North Carolina happens to be one of those states that has a state school system and not a system of schools, where we have a state curriculum framework that we put a lot of stuff in, that helps those teachers who may be out of field that can work in math and science, and many other areas.

My concern deals with, and I want you to talk about this, when we talk about science and math early, we moved and required algebra, one of the first states to do that, of all students. Because I happen to believe one of the challenges we face in this country, that algebra is the gatekeeper for getting into the whole area of math and science. It has been used historically as a filter rather than a pump primer. The only way you get it in is you require it. We required it of all students except those who have special disabilities. Amazingly, what happened? They started teaching it.

Now we did a lot to provide staff development for our teachers because this is a critical piece for all teachers. We continue to do it. So I would like to have your comments on that as it relates to how do we make this change in the system across this country where we have state and local schools, without being at the federal level being a hammer, but being an encouragement. Because I think math and science, as we look to the 21st century, that century is going to belong to the educated. If we don't do a better job, we are going to have a real problem.

I would like to hear your comments. The middle school study that Carnegie used, we use that to group, because I think you do have team teaching. I would like to hear your comments on how we get to this group of youngsters we aren't now reaching.

Chairman EHLERS. Is that question addressed to a specific person?

Mr. ETHERIDGE. Well, I would like to hear from all of them if they have enough time, to just briefly touch on it, be brief with your question. But more specifically, I would like to hear from Mr. Harrison, because he made one comment, and Dr. Rubin. Maybe start with her if we could.

Chairman EHLERS. If those two will answer the question, we are running over time. We will first go to Mr. Harrison, and then Dr. Rubin.

Mr. HARRISON. It's good you chose me, because my response will be real short. I don't know how to address it in the United States. But to also look at your other issue that you brought up prior, if you go to Ecutel, you will see it looks like the UN. I mean we have everybody there. In discussions with them, and as I mentioned earlier, it is not an option. It was my high school experience that if you did not pass algebra, you were filtered out rather than promoted to calculus and all the more advanced mathematics. I agree. That should not be the case. In fact, I think we ought to pile it on, make more, so that at least something will funnel through. That is my simple response.

Chairman EHLERS. Dr. Rubin?

Dr. RUBIN. Well, I can be very brief and say that the board has stated in its report that the standards should be for all, and the expectation should be that all students will live up to these expectations. I am not surprised to hear you say it worked, because I think once these higher standards are in place, it will work.

Chairman EHLERS. The gentleman's time has expired.

Next we will recognize the gentleman from Oregon, Mr. Wu.

Mr. WU. Thank you, Mr. Chairman. Thank you for organizing this hearing on two areas which are two of my favorite, most passionate areas, education and science. I would also like to congratulate you on your doubling time, and also Ms. Johnson on her doubling time in nursing in the United States Congress. I might add that I am a software attorney. Well, recently retired software attorney. I understand that 39 percent of representatives in this Congress are attorneys. If that percentage were cut down a little bit, it probably would not hurt the country. [Laughter.]

Because I very much understand the need for more people well trained in technology, science, and mathematics. My Congressional district is sometimes referred to as the "Silicon Forest of the Northwest." We have had dire shortages of trained individuals. We have a shortage of people coming out of our own educational pipeline, and we have a shortage of people coming out of the H–1B pipeline also. So I want to recognize the problems that you all are addressing.

I also want to highlight that there are some successes going on in our country. In our community, we have something called Saturday Academy, which is a science booster, science and math booster program. It runs on Saturdays, therefore the name. But it is partially funded by the National Science Foundation, and partially founded—funded by private contributions. It is a very intelligent leveraging of federal dollars into a program run on weekends for public high school students. We brought some folks out to see the program just to shine a spotlight on some things that are going well.

That leads to my question. It is sometimes most fun to talk about folks who aren't here. This program is substantially funded by the National Science Foundation. It is my understanding that NASA has a science and math education component, or science education component to it. The Department of Energy has a component in this arena also.

It is also my understanding that all three agencies are rapidly withdrawing from the field, getting out of K through 12 education. I would like to hear your opinions about that. Is this something which is first of all real? And next, if so, is this something like high schools when they get in a budgetary pinch, you know, cutting football, basketball, and the music program first to get the parents to address the budget issues first and foremost?

Chairman EHLERS. Does anyone wish to respond in the minute-and-a-half remaining?

Dr. BYBEE. I'll respond.

Chairman EHLERS. Dr. Bybee?

Dr. BYBEE. I think the instructional materials in the programs that the National Science Foundation—I would add National Institute of Health does some work in this area, NASA, Energy, have all made an extraordinary contribution to science and mathematics education in this country. I hope they are not decreasing their funding or decreasing funding for specific areas in K to 12 or some way or another reallocating that.

The science education and mathematics education, and I would add the technology education community, needs the innovation and the ideas that are coming from those agencies. It is just vital I think, as a new and innovative approach to what we are doing. They support it.

Dr. MALCOM. Let me just say that it has been very difficult I think to sustain support for education within the mission agencies, because the first thing is that the legislators are basically going to look at is to say "Well, aren't you outside of mission?" I don't think that any agency can afford not to be involved in the human resources development part of its mission. Otherwise, it will find itself without the next generation of regulators, of its own workforce. I think that this is one of the problems that we continually—and challenges that we continually face.

Mr. WU. Mr. Chairman, may I have time for one more question?

Chairman EHLERS. Your time has expired, I'm sorry. But we will have a second round.

Let me just make one comment to add onto this. These are excellent programs. But remember Dr. Rubin's original question about sequencing structured programs. Many of these are tossed into some schools, but not in others. So that is what our Committee has to look at. It is a very good question. But the question is, how can we incorporate these wonderful things into our regular programs throughout the Nation? Thank you.

The gentleman's time has expired. Let's see, Mr. Larson is next, yes.

Mr. LARSON. Thank you very much, Mr. Chairman. Let me follow up on what I hope was the question of Congressman Wu. With respect to maintaining a competitive edge in the global economy, and with the issue of uniformity and making sure that all of our students are not left behind, especially in the area of math and science, what kind of thinking has been given to focusing our agencies on delivering the technology, the actual infrastructure so that all public schools can have access to distance learning and to the very science that we need to propel and take us into the next century? Any member.

Chairman EHLERS. Yes. Ms. Kaslow?

Ms. KASLOW. I would say that it is happening in pockets, and successfully where it is happening. But it is a struggle for municipal governments—which are generally the ones that are succeeding in doing this—to get the funding, either state or federal funding for this.

I know one example, fairly recent in New Jersey. They are getting incremental grants to increase the transfer of technology, which is extremely important as you know. There is a virtual vacuum in many schools, technology. We are not just talking about depressed areas, but robust areas as well. Given that the economy is moving along at a fairly rapid clip, if not now, when are we going to do this, given the surplus. If we could put some emphasis on education, this is certainly a great tool.

The programs are uneven, as the chairman mentioned. One element to circumvent the unevenness is to get the technology in the schools.

The private sector must be—is engaged and must be engaged further. They are the ones with the technology. They are the ones who have the great incentive to do so. We have heard from Mr. Harrison, there is an incredible shortage of technologically-advanced folks. To hire much less technologically-competent folks at the basic level, private sector businesses need to be engaged through any number of incentives to get this stuff out.

Chairman EHLERS. Thank you. Dr. Malcom?

Dr. MALCOM. I served as a member of the PCAST panel on technology and education a number of years ago, and recognized very much the kinds of issues that you are addressing here.

I think the most recent figures that I saw shows that we are starting to get the technology into schools and we are starting to get Internet connectivity into the schools, and that that problem will probably solve itself within the next three to five years.

A more difficult problem, which we must face, is that of how do we actually prepare teachers to use the technology to reinforce the kind of content and pedagogy that we think is absolutely essential, not just in science and mathematics, but also in the other areas where it is possible to use it. The fact that you can get at primary, original source materials, for example, when you are dealing with history, I mean there are just really incredible opportunities. But the professional training and the professional education opportunities that are needed are ones that are really essential, and that we are going to have to deal with, along with the issue of the availability of hardware, the availability of robust and appropriate software, and the availability of connectivity.

I think that the last issue that we really do have to focus on is this research piece that Dr. Rubin mentioned earlier, that the Science Board talked about. We need to know what difference that makes, and we need to know what is actually most effective in terms of actually delivering the content.

Chairman EHLERS. Any further response? Mr. Harrison?

Mr. HARRISON. Yes. One more. I don't know what agencies are doing, and I am not sure exactly what the initiatives are, but I can say of those schools that have access to technology and where the kids are using it, and I give a specific example. Dzung Tran, my partner, goes around to area schools and talks to the students. In one case, he went to Thompson Elementary School over on L and 12th. He was amazed by the type of questions these 10 and 11-year-old kids were asking. All of them each had a high level of access to the Internet. They were able to do research on careers. During career day, he was there to talk about what would essentially be a high school level question and answers, careers in engineering, computers and science and engineering particularly.

These kids were savvy. They understood the concepts. They were asking him questions, how much he made a year, and would it be worthwhile to go into that area. [Laughter.]

To be that advanced, that adult, I thought was very interesting. I think it just, it makes them want to learn more. If we can just fuel that, we will be okay.

Chairman EHLERS. The gentleman's time has expired.

Mr. LARSON. I kind of figured that. I couldn't agree with you more though. Thank the three of you for your responses.

Chairman EHLERS. The final questioner on the first round is Ms. Sheila Jackson-Lee.

Ms. JACKSON-LEE. Thank you, Mr. Chairman, and thank the Ranking Member Brown, and thank Congresswoman Johnson, and the entire committee for their vital hearing. I would like to, Mr. Chairman, have my opening statement put in the record. I ask unanimous consent.

Chairman EHLERS. Without objection, so ordered.

Ms. JACKSON-LEE. Thank you very much. Let me emphasize a point or two and ask for a comment. First of all, Dr. Malcom, I am delighted that you included in your statement the H–1B visas. As a member of the House Judiciary Committee, and now ranking member on Immigration and Claims, I was intimately involved, and albeit I wanted to be responsive to our industries, I was a little aghast, I was just wishing that we could have found the numbers of trained individuals in the United States to be able to fill those positions. You don't want to penalize industry, but on the other hand, you are saying a country that prides itself for its creativity and uniqueness and innovativeness, and here we are begging to have people to serve in these technological positions.

I also was drawn to your statistics dealing with bachelor degrees. I have been reminded by my colleagues in the House of different ethnic backgrounds that education itself is something that we need to help improve for all children. I want to make that very clear and go on the record that I appreciate that sometimes we say disadvantaged, and in fact we have a problem in educating all of America's children, bringing all of them up to the bar. I want to go on the record to say that I am committed to that.

But I was struck by the fact that in engineering, whereas we had said in 1996, and I know the numbers go down, 47,000 male, 10,000 female, which is an increase but still very low, but 6,000 minority. Then in computer science, 16,000 male, female 6,000, and then 3,000 minority. So I do want to highlight that.

Here is my question to you, Dr. Malcom. I am glad Mr. Harrison mentioned those interesting questions of 11-year-olds. A school in my district by the name of Garden Oaks decided to organize parents and put in a science lab. They funded it themselves. I went to its opening where the parents came. There were rocks, and there were various other hands-on. It was fun.

We know that science and math and ultimately engineering, can be fun. The disaster is, or the problem is do we actually do that. Are we blaming the victim, the children, when in fact what are we doing creatively to make it fun, to bring the business community or the players in this into the school system. Then if I might use a word that we don't want to use here, "get something done," because I think this is a good oversight hearing, what would you instruct us to get done to help move this issue? Dr. Malcom, if you would.

Dr. MALCOM. Thank you very much for your question, I think. If you look at those numbers, one of the things that really is very striking about it is that had it not been for an increase in the female participation and the under-represented minority participation, the numbers would have gone down even more. I think that this basically shows that there really is an untapped reservoir.

If you look at the numbers, see I only gave you 1989. I didn't show you mid-1980s. If you look at mid-1980s, you will find, for example, that that was a high water mark for young women receiving bachelors degrees in computer science. And that between that period and today, there has been a loss of 53 percent of those bachelors degrees from young women. Now that to me says that there is something wrong with the instructional programs that essentially would take very smart people, very capable people, and over half of who is showing up in our higher education institutions, and essentially disenfranchise them and put them in the position of not seeking these programs.

So under those kinds of circumstances, I would have to ask can we find programs that are being successful? What are the characteristics of those programs that are being successful in training large numbers of students in very effective ways? Can we transfer the knowledge from the ones that are effective to the ones that maybe aren't so effective? I think that there is a lot of research here that we—and I know that the last thing people want to do is basically look at just research, but this is action research. This is looking at specific instances so that we can in essence migrate those practices into something else. It means beginning early, but it also means staying with the students. Often times, these students will come into our colleges and universities saying that they are going to major in science or mathematics or engineering or computer science, and while they are in those programs, they are not retained in those programs.

I was at a meeting on graduate education. We find that a lot of students are not going into graduate education because no one ever talks to them about going into graduate education, and they don't have the information about going into graduate education. Yet we have some mentors who have been exceedingly effective in terms of moving students in and through graduate education. What are they doing that is different from what other people are doing?

I think we have got to inform ourselves about exemplary practice, and then start to move that through the system. We can get those numbers up. I don't think our kids are any less intelligent or excited about good instruction than anybody else. I think it is a matter that we have to get on the case and be able to give some specific guidance to people who are in those roles as mentors and teachers and advisors.

Chairman EHLERS. Very well said. That is what we are hoping to do in this study.

The gentlewoman's time has expired. I think we have completed our first round, so I will open the second round.

Dr. Mundy, in your original statement, you talked a bit about training of teachers. I understood that to mean training of future teachers while they are in colleges and universities and so forth. Then in your response to another question, you talked about training of existing teachers. I think both of those are extremely important topics, and something that deserves far more attention than it has been given.

My question to you is what could we as the Federal Government do to strengthen the training and perhaps even the certification standards or changing them—I shouldn't say strengthen—but changing them. In the case of those students who are currently in colleges and universities and also those teachers who are already teaching.

Dr. FERRINI-MUNDY. Thank you, Mr. Chairman. I appreciate the question. I think to make the point that considering both the pre-service education of teachers and the continuing learning of teachers together, to think about that as a continuum is a very important thing to do, particularly as the content demands for teachers will change over their careers and curricula will shift, and emphases will shift. This notion of thinking about their work as a matter of continued learning is important.

I also wanted to try to encourage that we think about this as an infrastructure issue. When we think about how teacher education is done, both for pre-service and continuing teachers, it is really through an array of institutions. Higher education has a role in teacher ed. Private non-profit organizations are involved in teacher ed. Professional societies are involved. School districts have major involvement. We have in a sense quite a large an uncoordinated system that is working on the problem of teacher education.

You think we don't have clear agreement about what needs to be done with students at different points in their educational career, K–12 in mathematics and science. We have far less agreement about what teachers need to be learning at different points in their careers and how to do it. So my hope would be that through various kinds of federal programs, we could move toward a focus on coherence in the infrastructure, on coherence and focus in what teachers need to know and be able to do, and to supplement that work with research about teacher development across their careers.

So in summary, I think focusing on teachers, learning as a career-long activity, and getting much more consistency in the discussion across all of these different entities that involve themselves in teacher education.

Chairman EHLERS. Very good response. I hope we can contribute to that in this process. We will certainly pursue that, and we may be in touch with you further on that.

Yes, Mr. Kaslow, I noticed in your comments you talked a bit about the Council on Competitiveness report and what industry was doing in training. Did you, in the course of that study, or do you happen to know how much money is spent in the United States on education and training by industry, commercial establishments and so forth? And how that compares to the total amount spent on education in this country? I should say spent on K–12 education in this country.

Ms. KASLOW. The latter, I don't know. It is about $55 billion, but it is really—it's not a—I don't trust these numbers. These numbers are thrown by various——

Chairman EHLERS. You are saying $55 billion is spent by industry?

Ms. KASLOW. Industry, but it's not a good number because these are just the numbers that folks have come up with, various interest groups. There is no hard number.

Chairman EHLERS. Okay. My next question, which you also won't be able to answer then, is how much of this would you consider remedial education and how much of it is job-specific training that would be required regardless?

Ms. KASLOW. Unfortunately, the Lion—I do know this, because just from practical field work and hearing from various constituencies. The lion's share, unfortunately, is remedial. It is not just remedial one time, two times. There are almost all the new entrants into the workforce need remedial. You mentioned the teaching of existing teachers, which I think is a point that cannot be underscored enough. The teaching of incumbent workers is something—you know, folks might assume once they are there, they are doing their job. No. Keep going. No. It is definitely not the case.

There is a tremendous barrier that we have with incumbent workers who are very comfortable in their positions, especially, unfortunately, especially many of the unionized workers, that just know what they know, feel what they are comfortable with, what they know, and afraid of what they don't know and don't want to learn it. This is changing. It is a psychological change as well as a practical change. But vast sums are invested just to get them to have an absorptive capacity, to learn how to learn. It is not just at the lowest rung of the workforce. It goes all the way up.

We are talking now about science and math and technology and the info tech sector. We have to remember, this problem is certainly not isolated to that cadre. It goes throughout the workforce. It is the incumbent, it is the new entrant. It is unfortunately the would-be entrant.

Chairman EHLERS. Thank you. My time has expired.

Ms. Johnson, do you have any further questions?

Ms. EDDIE BERNICE JOHNSON of Texas. No.

Chairman EHLERS. Thank you. Mr. Smith has another one I know.

Mr. SMITH. Thank you, Mr. Chairman. Let me address another question to Ms. Kaslow, if I might. Let me point out something that we all know. That you can't talk about American competitiveness without talking about the world economy. So for that reason, I think you were right to point out in your prepared statement, and let me read the sentence, "Foreign workers who are imported to the U.S. underscore just how essential skills are to worker marketability. They reveal how the ill-equipped American worker is at risk of being cast aside for the international with know-how."

Let me just ask you to expand on that, if you would. What did you mean when you said the American worker might be at risk of being cast aside? I assume you meant losing jobs, seeing wages depressed and so forth. Is that right?

Ms. KASLOW. Right. It is often assumed that, especially this is born of the NAFTA debate in particular, that firms will just simply pick up and go abroad. That is a very expensive proposition. True, firms are——

Mr. SMITH. But when you said American workers are at risk of being of being cast aside, that means American workers in this country might lose their jobs and might see their wages depressed?

Ms. KASLOW. That is true, or wages not realized.

Mr. SMITH. Okay.

Ms. KASLOW. If I may finish. It has little to—there is a distinction between the firm going abroad.

Mr. SMITH. Right.

Ms. KASLOW. U.S. firm going abroad, and the firm staying here. There are investments that have to be made here as well. It is a cost-benefit analysis.

Mr. SMITH. No, no. I totally agree with that. Don't misunderstand me. I am not disagreeing with you. I am just trying to focus on the problem that you have stated well, which is the risk of being cast aside here in the United States, of American workers.

As you know, and as Dr. Malcom mentioned a while ago, the H-1B category is a category of high tech kind of workers. Last year, Congress approved admitting I think 115,000 this year, and it is around 100,000 for several years. Do you think those—admitting 100,000 high tech workers is good for ill-equipped American workers?

Ms. KASLOW. This is a circuitous way to go about this, but it is good in the interim while we have these shortages. It is good for workers because the future of the U.S. economy banks very much on how industry——

Mr. SMITH. I know it is good for the future, but what about the American workers who are unskilled today? How is it good for them?

Ms. KASLOW. Well they are not going to get those jobs anyway right now. I mean obviously.

Mr. SMITH. You don't think we ought to be training them immediately?

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Ms. KASLOW. Of course we are. Of course we should be and we are. Let me say that--you know, Dr. Malcom talked about college and university experience, and this is an important point so bear with me for a moment. It is very, very important to know that there are many other options being realized right now by students. There are a lot of folks who are going to community colleges, vocational training, et cetera. Community colleges are very, very dynamic, a very vibrant part of training for the work force. These community colleges are very much driven by the bottom line. As a consequence, they are making it their business to respond to industry needs. That is just in time training, educating, getting folks into the workforce for high skilled jobs.

Mr. SMITH. I think that is all for the good, but I want to go back and see if I understood you correctly. You said that having so many high tech workers come to the United States was good for ill-equipped American workers because they couldn't get the jobs anyway? Is that your statement?

Ms. KASLOW. Oh boy. I think you are talking in a macro economic sense. We are not talking about here and today. We are talking about a longer term. Here and today——

Mr. SMITH. I am talking on the present. Not the future.

Ms. KASLOW. You will have to let me finish this.

Mr. SMITH. Is it good for the American workers today? By the way, this is a bill that I supported, and I found myself on the side of the administration trying to protect American workers, so don't misunderstand what I am saying. But you made the statement that you didn't think these high skilled folks or what you call the international with know-how, in your official statement you said that they were putting American workers at risk of being cast aside. Do you still think that that's——

Ms. KASLOW. Let's be very clear here. Okay? Allow me to finish a sentence and we will be very clear.

Mr. SMITH. Okay.

Ms. KASLOW. The workers who are being cast aside are those— the people that Mr. Harrison are talking about, is talking about, and many, many, many other business owners, not just high tech. Okay? These are folks who, people who cannot, cannot——

Mr. SMITH. Are they being cast aside——

Ms. KASLOW. Let me finish.

Mr. SMITH [continuing]. By the international with know-how or not?

Ms. KASLOW. Let me finish, because this is getting a bit frustrating.

Mr. SMITH. Well, I am just reading from your own statement.

Ms. KASLOW. Well, I would like to explain the statement.

Mr. SMITH. I am afraid I get the prerogative of asking the question. But let me ask my question one more time.

Ms. KASLOW. But your question has been asked many times, and you haven't allowed me to answer.

Mr. SMITH. Let me ask my question, and then if you can just answer yes or no, because I am just using your own words.

Ms. KASLOW. I am not going to answer yes or no, because you are asking a question on a partial statement.

Mr. SMITH. No, no, no. I quoted the sentence in toto. You are welcome to read more of it if you want to. But is the American worker today, not in the future, today being put at risk of being cast aside by these highly skilled workers whom you say we are importing?

Ms. KASLOW. Yes, yes. But that is not the question you asked me. You asked me was it good for them to bring in skilled workers. I am saying it is an inevitability in the short-term. Is it good for them? Right now, it behooves industry and it behooves the economy at large to get workers in to do the job that industry is trying to do.

Mr. SMITH. But I assume it's not good for them if they are being put at risk of being cast aside.

Ms. KASLOW. They are cast aside.

Mr. SMITH. And that's not good.

Ms. KASLOW. Of course it's not good.

Mr. SMITH. Okay. And the direct cause of that is the international with know-how, according to your statement.

Ms. KASLOW. The cause of this is the inadequacy of the American skill base. That is the cause. It is not the internationals with know-how.

Mr. SMITH. Okay. So do you want to retract that statement in your prepared statement?

Ms. KASLOW. I think, with all due respect, you are making this quite convoluted.

Mr. SMITH. Let me read the sentence once more, Mr. Chairman, with your indulgence. "Foreign workers who are imported to the U.S. underscore just how essential skills are to worker marketability, and they reveal how the ill-equipped American worker is at risk of being cast aside for the international with know-how."

Ms. KASLOW. Correct.

Mr. SMITH. Okay. So you agree with that statement?

Ms. KASLOW. Yes. I wrote it. But it is not as you are interpreting it.

Mr. SMITH. Okay. And you think that it is—is it good or bad for the American worker to have all these folks come in with know-how?

Ms. KASLOW. In the interim it is an inevitability.

Mr. SMITH. Is it good or bad in the present?

Ms. KASLOW. To keep industry productive——

Mr. SMITH. So it's good?

Ms. KASLOW. I am not going to be boxed in the corner you are trying to box me into.

Mr. SMITH. I am using your words.

Ms. KASLOW. Right. But you are using your interpretation.

Mr. SMITH. We have an acute—we have an acute skill shortage. We also have an acute political sensitivity, a surplus.

Ms. KASLOW. Right. Which I think you are speaking to. I am talking about reality and what is inevitable right now, which is first of all, we don't have an adequate skill base. We have industry that is screaming for new, for labor.

Mr. SMITH. We all acknowledge that. But I think from your own statement, which I think you have now agreed to, it is not all good. Some people are put at risk by our current policy.

Ms. KASLOW. They are put at risk by their own position now in the labor——

Mr. SMITH. You said they were put at risk by importing foreign workers, the international with know-how.

Ms. KASLOW. But they are at-risk, they are in that position because of the inadequacy of their own skill base. It's the cause of their——

Mr. SMITH. So you want to strike the last part of your statement?

Ms. KASLOW. No. I do not. No, I do not.

Mr. SMITH. Okay.

Chairman EHLERS. The gentleman's time has more than expired. If you wish to pursue this, we can either have a third round or——

Mr. SMITH. That's all right. Someone was volunteering to answer the question, but I think my time is up, Mr. Chairman. Maybe we can discuss afterwards.

Chairman EHLERS. All right. Fine. Thank you. There's always the boxing ring in the gym if you wish to pursue it. [Laughter.]

Thank you very much. Final second round question. Mr. Larson, do you have something else?

Mr. LARSON. Thank you, Mr. Chairman. Yes. I would just like to follow up on a line of questioning before. I believe it was Dr. Malcom that said that you think that this problem may be solved technologically within the next three to five years. While I completely agree with you about the need to train teachers, et cetera, and especially to train them currently while they are going through our colleges and universities, but also to remediate where necessary, the teachers that are currently in the workforce.

My concern is that, given the need for us, both in terms of connectivity, et cetera, it seems as though a government that spends close to $50 billion in research to put up what could be a defense technology imaginal line, but can not invest money to make sure that all of our children have access to the information superhighway, we have got our priorities wrong.

It is heartening to hear the business community come forward because I believe that ultimately it is they who will drive this issue. I would be interested in your comments on that. Five years may be too late for another generation of children.

Dr. MALCOM. I agree with you. I agree with you that it can't come soon enough. But I think that there are other places that we have to be concerned about as well, and where I would hope that there would be some Government investment.

One of the biggest discrepancies is the availability, that between technological haves and have-nots is actually the access to home computing.

Mr. LARSON. Right.

Dr. MALCOM. Which is a much bigger and more thorny kind of an issue. A lot of us proposed that we can start having community technology centers, that our libraries be much more technology centers that are available to the people within the community.

We have advocated, and actually helped to support and manage industry setting up technology learning centers. We actually work with and help Intel in terms of managing two of their centers, one in Sacramento and one in Portland, Oregon. We have got to have these kinds of centers, public access, public use centers within the community in ways so that kids aren't just—it isn't just a matter of being tied to school, because a lot of the effort actually goes on in the after-school hours.

I would hope that this would be another area, in addition to the concern about schools, that this would be another area where we can get this kind of investment. Because putting that investment in there isn't just a way of addressing the educational need. It is also a way of addressing the issue that I spoke largely to within my own oral testimony. That was how do we deal with the education of the adult public who are no longer within the schools. There is an opportunity there to engage with those parents of those kids as well as with the kids themselves around the technology through these kinds of community technology learning centers.

I know that those things are in place. I would just want to encourage both the school and the community-base for technology.

Chairman EHLERS. Any further questions?

Mr. LARSON. No.

Chairman EHLERS. Thank you very much. Thank you to the members of the Committee who were here.

Thank you especially for the witnesses. I know it has taken time out of your day. We appreciate the extra effort. I am very pleased. This has been a good kickoff. The panel has been very balanced in a number of ways. The ideas that are presented have covered the field that we wanted to cover. We will consider your comments and use those to decide where we go next.

I would also encourage the members of the panel, I hope you will maintain your interest in this. I would welcome your comments, either by telephone or in writing, as to how you think we should proceed with our inquiry. I hope you will also maintain an interest in it, and continue to advise us as we go along.

So thank you for taking the time to be here. We certainly appreciate your participation and the wisdom of your testimony. Thank you very much.

The hearing is adjourned.

[Whereupon, at 12:02 p.m., the Committee was adjourned.]

APPENDIX I: Opening Statements from Members of the Subcommittee on Basic Research

OPENING STATEMENT BY
THE HONORABLE F. JAMES SENSENBRENNER, JR.
CHAIRMAN
COMMITTEE ON SCIENCE
UNITED STATES HOUSE OF REPRESENTATIVES

WHY AND HOW YOU SHOULD LEARN MATH AND SCIENCE

March 17, 1999

I want to welcome everyone here today for this first in a series of hearings the Science Committee will be holding on science, math, engineering, and technology education.

As you may know, last year I charged Congressman Ehlers with developing an approach to a new national science policy. As a result of over a year's work, the Committee released the study, *Unlocking Our Future: Toward a New National Science Policy*, a major focus of which is math and science education. As the Report notes, math and science education is the road that will ensure American preeminence in technology and prepare American students to be able employees, smart consumers, and engaged citizens. I am pleased that the Committee is following up on this aspect of the Science Policy Study, as education is one of the most important issues we must address.

By now it is old news that U.S. students are not performing to the level of their peers around the world. In fact, U.S. students perform near the bottom. Clearly, American children are not receiving an adequate education in math and science, and we as a Nation should be concerned. We can and must do a better job of preparing our young people for the 21st century, and we have an obligation to see that students receive the education they will need if they are to compete and win in the global marketplace of the future.

This series of hearings will serve as a comprehensive examination of current science and math education, the directions science and math education may take in the future, and programmatic reforms that may be necessary to ensure graduates of U.S. schools are well prepared. The examination will require assessing the current situation and understanding the specific weaknesses in our education systems. The most technologically advanced economy in the world requires the most scientifically-literate workforce on the planet.

I am pleased that my colleague Vern Ehlers of Michigan will be chairing this series of hearings and taking the lead in this most important issue. Before I turn over the gavel to Congressman Ehlers, I would like to thank the witnesses for appearing before us today and look forward to hearing their testimony.

Opening Statement
Congressman Vernon J. Ehlers
Why and How You Should Learn Math and Science
March 17, 1999

I want to welcome everyone to the first in a series of hearings the Committee on Science will be holding this year examining math and science education. As most of you know, last year I was asked by Speaker Gringrich and Chairman Sensenbrenner to head up the Science Committee's effort to develop a new national science and technology policy to lead us into the next century. One of the major areas addressed in the resulting Science Policy Report, *Unlocking Our Future: Toward a New National Science Policy*, is the vital need to fortify our system of mathematics and science education, from preschool to research universities.

Education is the cornerstone of a national resource, the intellectual capacity of our children. Our K-12 education system serves three main purposes: it is responsible for preparing future scientists and engineers for further study in college and graduate school; it provides a foundation for those who will enter the workforce in other capacities; and it provides scientific and technical understanding so that citizens may make informed decisions as consumers and voters. We must continuously and diligently nurture future generations in order to provide them the opportunity to contribute and prosper in the technology-based world of tomorrow.

Recent assessments of student performance in science and math showed that although our fourth graders did relatively well in both math and science, our 12th grade students are far from the goals set by the Bush Administration and the 50 State Governors of being first in the world by the year 2000. We have much to be proud of in our national education system, but we ought always to be seeking to address our weaknesses and to improve our performance. By combining the lessons learned through the TIMSS analysis with the many discussions that we have had on this subject in the past, we can begin to address the steps necessary to rectify the deficiencies in our system and effectively pursue our goals.

In addition to the need to stimulate future curiosity and innovation in science and technology, I believe that it is not only for the sake of learning math and science fundamentals that these subjects must be taught. In today's world, these disciplines have a large and direct impact on many aspects of our lives. Learning the inquiry-driven process underlying math and science principles helps develop the human intellect, aiding the learning of other, seemingly unrelated, subjects. To enter the workforce in jobs ranging from an office worker to an aerospace engineer, technical competence and problem solving skills -- the fruits of a solid foundation in math and science -- are essential to exercising our roles effectively. In a recent study by Thomas Burkman entitled, the Role of Technology In

Future Schools, it is pointed out that "data from the U.S. Census Bureau and the Department of Labor have shown that by the beginning of the next century, 60 percent of the new jobs will require skills possessed by only 20 percent of the young people entering the labor market." Unless we improve the education our children receive, they will not be adequately prepared to compete with their international peers in a global economy.

An additional realm of society that is heavily influenced by the development of science and technology, is that of public policy. Today and in the future, lawmakers and their constituents are faced with complex issues created by our technological success. Genetically modified foods, clean air regulations, global warming, privacy concerns surrounding our genetic information, cloning and Y2K are all issues which, as a nation, we must confront. If our citizens do not have the educational background to understand the relevant questions and their debatable answers, it will be impossible for them to make informed decisions about how they wish the country to proceed. We must arm all students with the knowledge and skills to interpret scientific information, so that as adults they will be prepared to intelligently participate in policy decisions that effect their world.

Before we hear from our witnesses who will elaborate on the reasons why math and science education are so important, I would like to make one last point. This hearing is not intended to provide us with answers, but rather I hope that this hearing will stimulate questions that we should ask as we seek solutions. We must ensure that through our education system, we instill children with the motivation and desire to obtain the fundamental skills and knowledge to thrive in a technology-saturated future, in terms of their occupations and their personal lives as consumers and voters. I look forward to receiving the testimony of our distinguished panel as we begin this very important process.

Statement of Congressman Nick Smith
Chair, House Basic Research Subcommittee

House Science Committee Hearing on Math and Science Education

Wednesday, March 17, 1999

10:00 a.m.

Mr. Chairman,

I am very pleased that the House Science Committee has chosen the issue of science and math education as its first hearing topic of the 106th Congress. As chairman of the Basic Research Subcommittee, which has jurisdiction over K-12 science and math education, I am aware of the vital role that the proper training of the next generation of scientists and mathematicians will have on our society, as well as the importance of increasing generally literacy in these areas as well.

As a legislator, education has always been one of my main concerns. Ensuring that science and math are considered to be vital components of a traditional K-12 education is one of my goals as chairman of the Basic Research subcommittee. Also, the traditional concept of liberal arts in college must include science and technology courses tat are necessary to better understand the world we live in. Doing so will benefit not only those students who will go on to pursue science and math careers, but those who are seeking careers outside these fields.

We know that not enough students are choosing to enter the math and science fields once they enter college. By exposing all children to a basic math and science education, we can help ensure that more students will ultimately choose science, math and engineering majors when then enter college.

Even those students who are pursuing other fields, though, are finding that their progress in college is being impeded because of their failure to learn an adequate amount of math and science in their primary education. Math in particular is cited as the subject that has the lowest student success rate and is most feared and postponed by students. The result, according to a recent story in the *LA Times*, is that many students in junior and community college are unable to obtain their degrees in fields such as preschool and art teaching, office administration and counseling. Because we haven't learned enough about how to teach them an adequate amount of math early on in life, these students are now finding their progress put on hold, perhaps indefinitely.

This hearing is the first in a series that will focus on reforming science and math education. This is not an issue that can be addressed quickly, but needs to be the subject of a long term commitment. The House Science Committee will continue to take the lead in this important area by adopting a new science policy that focuses heavily on educational issues.

Today's hearing marks an important first step towards implementing these goals.

Statement of Representative Judy Biggert (R-IL)
House Science Committee Hearing
"Why and How You Should Learn Math and Science"
March 17, 1999

I want to commend the Chairman for holding this hearing to highlight the importance of math and science achievement for our nation's students. Illinois is home to several fine institutions dedicated to this cause, and I look forward to working with the gentleman from Michigan on this issue. In addition, I would like to thank our witnesses for being here. I'm anxious to hear your testimony about how our students can better learn math and science.

The district I represent is home to the North Central Regional Educational Laboratory (NCREL), one of 10 federal educational R&D labs. Since 1994, NCREL has worked with a coalition of students, parents and teachers in Chicago's near north suburbs to achieve "First in the World" academic status in math and science.

The "First in the World Consortium" represents about 20 elementary and secondary districts and approximately 38,000 students, along with NCREL. It also includes the Illinois Math and Science Academy -- our nation's only state-funded school focused solely on math and science studies.

The Consortium utilized the Third International Math and Science Study to compare the performance of its students in math and science to those from around the world. Student performance in the consortium was outstanding. Fourth-graders from these partnered schools were first in the world in science.

Members of this consortium still recognize the need to find ways for ALL students to achieve in math and science. NCREL and the partner schools continue to learn from the results of the study and apply what they are learning to improve student performance.

The Consortium gave Illinois students and teachers a glimpse of how math and science are being taught, and how our students are learning. Teachers are learning from this exercise too and developing professionally. I look forward to working with the Science Committee to ensure that students across our nation also can achieve first in the world status in math and science.

Eddie Bernice Johnson

OPENING STATEMENT
HEARING ON
WHY AND HOW YOU SHOULD LEARN MATH AND SCIENCE
BY
THE HONORABLE EDDIE BERNICE JOHNSON
RANKING DEMOCRATIC MEMBER
BASIC RESEARCH SUBCOMMITTEE

March 17, 1999

During the last Congress, the Science Committee held several hearings on the status of K-12 science and math education and on the efforts that are underway to improve student performance in these subjects. I am pleased to join Vice-Chairman Ehlers today in initiating a new series of science education hearings, which I hope will lay the groundwork for some specific legislative initiatives.

The basic question raised by this hearing is why is it important that students learn science and math? To those of us on the Science Committee, the answer is clear.

In the past, concerns about science education were motivated largely by the goal of ensuring a full pipeline of students moving toward careers in science and technology. But the realization that technology now infuses more and more aspects of daily life leads to the conclusion that all citizens need a basic grounding in science and math to function in an increasingly complex world and to lead fulfilling lives.

Most workplaces are becoming increasingly technological, while our society is becoming increasingly diverse. We are running the risk of a widening gulf between those with the training to thrive in this new work environment and those lacking the basic skills to qualify for the high-tech workplace.

To connect students to the technological workplace of tommorrow, I intend to introduce legislation soon that will encourage partnerships between schools and businesses in their communities.

My bill, called the Math and Science Proficiency Partnership Act, will target urban and rural areas whose students and their schools often lack the resources that more affluent areas have. Grants through the National Science Foundation will be awarded to school-business partnerships: to train math and science teachers and to teach math and science students. As an active partner with the schools, businesses will be encouraged to set up on-site internships and mentoring for students, to establish college scholarship programs as well as to donate computer software and hardware. I strongly encourage my colleagues to cosponsor this bill and hope that this committee will act on it favorably.

The nation must take advantage of the human resource potential of all our people if we are to succeed in the international economic competition of the 21st century. This will require that reform efforts in science and math education seek to engage and cultivate the interest of all children.

There is much evidence that young children are naturally interested in science and that grade school students in the U.S. perform well in science and math. This was shown to be the case in the recent results of Third International Math and Science Study, known as TIMSS. U.S. students at the fourth-grade level were near the top in this international comparison.

However, the picture changes for the worse as students move through the school system. By middle school, again from the TIMSS findings, U.S. students have drifted down to the average performance level of the international comparisons, well below most of our major economic competitors. And by the terminal year of high school, U.S. students are near the bottom of the rankings in science and math performance.

The TIMSS study gathered extensive data on teaching strategies, curricular materials, teacher development, and many other aspects of the school systems of the various countries. At today's hearing, we hope to explore whether analysis of this data has led to any conclusions that could inform educational reform efforts in the United States.

In general, we are interested in the views of our witnesses on ways federal education programs can contribute more effectively to the goal of improving science and math education, and particularly seek their views on possible unmet needs for support of relevant research and demonstration activities. Any recommendations they may have would be welcome.

Mr. Chairman, I congratulate you for calling this hearing, and join you in welcoming our witnesses. I look forward with interest to their testimony.

The Honorable Bob Etheridge
Extension of Remarks
Science Committee Hearing on Math and Science Education
March 17, 1999

Good morning. I want to thank the Chairman, the Vice Chairman and the Ranking Member for holding this important hearing this morning. And, I want thank each of you for your testimony here this morning. I am sure it does not come as any surprise to my colleagues on this panel that as the former Superintendent of Schools in North Carolina, the topic of science and math education is near and dear to my heart. As Superintendent, one of my primary goals was to improve science and math education for all children, particularly minorities. We did a number of things in this regard, including raising standards and requiring algebra in earlier grades. We also worked with local school systems to get children into the science and math pipeline earlier in their academic careers.

I also have had a strong interest in, and a deep concern, regarding the lack of minority representation in high-tech employment in America, and it is this issue I want to ask you about this morning. America's economic prosperity in the 21st Century depends on our success in the technology sector. That prosperity simply cannot be sustained if minorities are left behind. In a recent article in The New Republic entitled: "COLOR BLIND: The African American absence in high tech," the lack of minority participation in the fields of math and science is referred to as the "digital divide" between a computer-literate mainstream and people

of color. The article refers to a San Francisco Chronicle study which showed that African Americans only make up four percent of Silicon Valley's employment. The article discusses a number of possible reasons for the lack of minority representation in these fields, from outright discrimination to cultural attitudes in the minority community. Would you please comment on your thoughts as to why this disparity between the races in high-tech employment exists, and more importantly, what can be done throughout the educational process to encourage more minority interest and participation in math and science educational and employment opportunities. And Mr. Chairman, before they comment, I would like to say that I think as we continue to look at the subject of raising standards and improving science and math education, addressing the issue of minority participation in high-tech education and employment must be one of this committee's top priorities. And Mr. Chairman, I would like to submit the New Republic Article for the hearing record.

COMMITTEE ON SCIENCE

FULL COMMITTEE HEARING ON THE IMPORTANCE OF SCIENCE AND MATH EDUCATION

Opening Statement of Congresswoman Debbie Stabenow
of the 8th District, State of Michigan

March 17, 1999

Mr. Chairman, I applaud the Committee for conducting this series of hearings on the importance of science and math education. We have heard a great deal in recent years about how students in this country are not keeping up with their counterparts across the globe in these subjects. We also know how important a grounding in science and math are for success today and in the future. You only need to look as far as the classified section of any newspaper to realize that the high-tech industry offers an abundance of career options. However, without the proper education and training, many students will be unable to take advantage of these opportunities. The timing of this hearing is especially appropriate, with the House having debated the Ed-Flex bill last week. Given the fact that both parties are on record as wanting to do more for education during the 106th Congress, discussions such as this one will keep us focused on that goal.

The ability to work on these issues is a major reason I serve on this Committee. I am very interested in the ways that technology impacts our society, and its ability to spur economic and intellectual growth. I firmly believe that the revolution of the information age can and must reach all segments of society. The changing basis of the global economy will have bumps along the road, as we have clearly seen in the last few years, but as I mentioned above, exciting possibilities have also appeared that hold out great hope for everyone, including displaced workers, disadvantaged students, and women.

As leaders, it is incumbent upon us to make these possibilities available to our constituents. The first piece of legislation I helped introduce and enact made it easier for companies to donate computer equipment to schools. In addition, I have reintroduced two bills this Congress, H.R. 1075 and H.R. 1076, that would make it easier for teachers to acquire computers and computer-related training. I am the sponsor of Net Days and the Great Space Adventure in my congressional district, the latter of which introduces students and their parents to the world of science and math education through the wonder and adventure of space, and am currently leading the effort toward ensuring an adequate level of funding for the National Space Grant and Fellowship Program. In short, I believe very strongly in the importance of science and math education and have worked assiduously to increase awareness of these subjects among the students of central Michigan.

Mr. Chairman, Mr. Brown, I thank you for your leadership on these critical issues. As this series of hearings progresses, it is my hope that we will reach a greater understanding of why science and math education are lagging in the United States, and what steps we might take to reverse this trend. I look forward to hearing from our witnesses, and appreciate their time and expertise. I am especially anxious to take on the hard work that lies ahead for all of this in this arena.

SHEILA JACKSON LEE
18TH DISTRICT, TEXAS

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STATEMENT
CONGRESSWOMAN SHEILA JACKSON LEE
COMMITTEE ON SCIENCE
HEARING ON MATH & SCIENCE EDUCATION
MARCH 17, 1999

Sheila Jackson Lee

I would like to thank Vice-Chairman Ehlers, along with Ranking Member Brown, for holding this useful and important hearing on math and science education in the United States. I know that many of us on the Committee are very committed to education issues, and I am glad to see that it is the topic of our first hearing for the full Science Committee in the 106th Congress.

It is my hope that it is this topic which will define the work of this Committee during this Congress. It is a bipartisan issue, and one that will undoubtedly serve the interests of the entire United States, and not just a small segment of the research community. Improving our science and math education can buttress all of our efforts to keep our economy on high ground as we enter the 21st Century, and I believe that this Committee can provide substantial guidance to the rest of the House so that we approach the issue in a responsible and effective manner.

In fulfilling our task, this Committee must first review the current state of our education system. That includes a review of all of the necessary data that we have available to us. Just last year, in this Committee, we looked at the statistics compiled in the Third International Math and Science Study (TIMSS). I believe that the findings from that study were very helpful, but I hope we can look for more sources of information on this important issue.

As a testament to how effective our Committee can be on the issue of education, we can point to how we handled the issue of women in science just last session. If you would remember, several of the Members of this Committee were motivated to action by reports and testimony on why women were not getting involved in the hard sciences.

Some of the reports indicated that oftentimes, young girls who are interested in math and science when they are young, are later "turned off" to the subject as they grow older. Many felt that young girls would become disinterested in the field because they lacked female role models, and because girls are simply not encouraged by their teachers to pursue the sciences. As a result last year, we passed the Women in Science, Engineering, and Technology Development Act to assist in rectifying that problem. The passage of that bill, once again, shows how the Science Committee can work to promote science and math in education, and I hope we can do it again in this session, only this time addressing a different concern.

The concern I am the most concerned about is the lack of participation of minorities in the fields of science. We have seen it in almost every facet of the science community. Minority children do not have the same access to computers or the Internet that White children do. African-Americans and Hispanics have been unable to penetrate the job market in the fastest growing sector in our economy – the technology sector. And reports indicate that minorities continue to lag behind Whites on standardized science exams.

We must do something to address this issue, and I hope that my colleagues will join with me to make sure that no one is left behind as we move into the next century. I look forward to hearing from all of the witnesses, and working with you in the future.

APPENDIX II: Written Testimony, Biographies, Financial Statements & Answers to Post-Hearing Questions.

Statement of

Dr. Vera C. Rubin
Member, National Science Board

Before the
Committee on Science
U.S. House of Representatives
2318 Rayburn HOB

March 17, 1999

Mr. Chairman, Ranking Member Brown, and members of the Committee, I appreciate the opportunity to testify before you. I am Dr. Vera Rubin, member of the National Science Board and an astronomer at the Carnegie Institution of Washington.

The National Science Board is the governing board for the National Science Foundation (NSF) and also a national policy advisor to the Congress and the Administration.

My appearance today grows out of an NSB report, released just two weeks ago, titled "Preparing Our Children: Math and Science Education in the National Interest." With your permission, I would like to submit a copy of this report for the record. (It is also accessible at www.nsf.gov/nsb/documents.)

This NSB report is the result of a year-long review by a Board task force of which I was a member, created in the wake of the disturbing results of the Third International Mathematics and Science Study, or TIMSS.

The Board believes that it is both imperative and possible to develop national strategies to improve K-12 teaching and learning of math and science. These strategies must serve the national interest while respecting local responsibility for education practice and outcomes.

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The Board's report speaks to local schools, teachers, and parents. It also identifies roles that especially institutions of higher education, and the scientists and engineers within them, can play as citizens and educators in their communities.

Facing the Challenge

We all know that improving student achievement – in 15,000 school districts with diverse populations, strengths and problems – will not be easy. Education is a systemic challenge that we must face. It demands diligence and commitment by all "system" participants.

The future of the Nation depends on a strong, competitive workforce and a citizenry equipped to function in a complex world. The national interest encompasses what every student in a grade should know and be able to do in mathematics and science. Further, the connection of K-12 content standards to college admissions criteria is vital for conveying the national expectation that educational excellence improves not just the health of science, but everyone's life chances through productive employment, active citizenship, and continuous learning.

The high rate of mobility in today's society means that local schools have become a *de facto* national resource for learning. According to the National Center for Education Statistics, one in three students changes schools more than once between grades 1 and 8. A mobile student population dramatizes the need for some coordination of content and resources. Student mobility constitutes a systemic problem: for U.S. student achievement to rise, no one can be left behind.

The NSB report focuses on a complex of issues familiar to this committee. Our challenge is what to ***do*** about each issue and ***how*** Federal resources can support local action.

A core need, according to the NSB report, is for rigorous content standards in mathematics and science. All students require the knowledge and skills that flow from teaching and learning based on world-class content standards. That was the value of TIMSS: it helped us calibrate what our students were getting in the classroom relative to their age peers around the world.

What we have learned, from TIMSS and other research and evaluation, is that U.S. textbooks, teachers, and the structure of the school day do not promote in-depth learning.

Thus, well-prepared and –supported teachers alone will not improve student performance if other things are not changed as well. For example, more discerning selections of textbooks, instructional methods that promote thinking and problem-solving, the judicious use of technology, and a reliance on tests that measure what is taught. When whole communities take responsibility for "content," teaching and learning improve.

Accountability should be a means of monitoring and, we hope, continuous improvement, through the use of appropriate incentives.

The power of standards and accountability is that, from district-level policy changes in course and graduation requirements to well-aligned classroom teaching and testing, all students can be held to the same high standard of performance. At the same time, teachers and schools must be held accountable so that race, ethnicity, gender, physical disability, and economic disadvantage can diminish as excuses for subpar student performance.

Areas for Action

The NSB focuses on three areas for consensual national action to improve mathematics and science teaching and learning: instructional materials, teacher preparation, and college admissions. I'd like to touch briefly on each.

1. *Instructional Materials*

According to the TIMSS results, U.S. students are not taught what they need to learn in math and science. Most U.S. high school students take no advanced science, with only one-quarter enrolling in physics, one-half in chemistry. From the TIMSS analysis we also learned that curricula in U.S. high schools lack coherence, depth, and continuity, and cover too many topics in a superficial way. Most of our general science textbooks in the U.S. touch on many topics rather than probe any one in depth.

Without some degree of consensus on content for each grade level, textbooks will continue to be all-inclusive and superficial. They will fail to challenge students to use mathematics and science as ways of knowing about the world.

> *The NSB urges active participation by educators and practicing mathematicians and scientists, as well as parents and employers from knowledge-based industries, in the review of instructional materials considered for local adoption.*

Professional associations in the science and engineering communities can take the lead in stimulating the dialogue over textbooks and other materials, and in formulating checklists or content inventories that could be valuable to their members, and all stakeholders, in the evaluation process.

2. *Teacher Preparation*

According to the National Commission on Teaching and America's Future, as many as one in four teachers is teaching "out of field." The National

Association of State Directors of Teacher Education and Certification reports that only 28 states require prospective teachers to pass examinations in the subject areas they plan to teach, and only 13 states test them on their teaching skills. Widely shared goals and standards in teacher preparation, licensure, and professional development provide mechanisms to overcome these difficulties. This is especially critical for middle school teachers, if we take the TIMSS 8th grade findings seriously.

We cannot expect world-class learning of mathematics and science if U.S. teachers lack the knowledge, confidence, and enthusiasm to deliver world-class instruction. While updating current teacher knowledge is essential, improving future teacher preparation is even more crucial. The community partners of schools – higher education, business, and industry – share the obligation to heighten student achievement.

> *The NSB urges formation of three-pronged partnerships: institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts.*

These partnerships should form around the highest possible standards of subject content knowledge for new teachers, and aim at aligning teacher education, certification requirements and processes, and hiring practices. Furthermore, mechanisms for the support of teachers are needed, such as sustained mentoring by individual university mathematics, science, and education faculty, and other teacher support mechanisms, such as pay supplements for board certification.

3. College Admissions

Quality teaching and learning of mathematics and science bestows advantages on students. Content standards, clusters of courses, and graduation requirements illuminate the path to college and the workplace, lay a foundation for later learning, and draw students' career aspirations within reach. How high schools assess student progress, however, has consequences for deciding who gains access to higher education.

Longitudinal data on 1982 high school graduates point to course-taking or "academic intensity," as opposed to high school grade point average or SAT/ACT scores, as predictors of completion of baccalaureate degrees. Nevertheless, short-term and readily quantifiable measures such as standardized test scores tend to dominate admissions decisions. Such decisions promote the participation of some students in mathematics and science, and discourage others.

Acting as "all one system" means that the strengths and deficiencies of elementary or secondary education are not just inherited by higher education. Instead, they become spurs to better preparation and opportunity for advanced learning. Partnering by an institution of higher education demands adjusting the reward system to recognize service to local schools, teachers, and students as instrumental to the mission of the institution.

> *The NSB urges institutions of higher education to form partnerships with local districts/schools that create a more seamless K-16 system.*

These partnerships can help to increase the congruence between high school graduation requirements in math and science, and undergraduate performance demands. They can also demonstrate the links between classroom-based skills and the demands on thinking and learning in the workplace.

4. Research

A fourth area that underlies the three above is research. Questions such as *which* tests should be used for gauging progress in teaching and learning, and *how* children learn in both formal and informal settings require research-based answers.

The National Science Board sees research as a necessary condition for improved student achievement in mathematics and science. Further, research on local district, school, and classroom practice is best supported at a national level and in a global context, such as TIMSS. Knowing "what works" in diverse settings should inform those seeking a change in practice and student learning outcomes. Teachers could especially use such information. Like other professionals, teachers need support networks that deliver content and help to refine and renew their knowledge and skills.

> *The Board urges the National Science Foundation and the Department of Education to spearhead the Federal contribution to science, mathematics, engineering, and technology education research and evaluation.*

Efforts such as the new Interagency Education Research Initiative are rooted in empirical reports by the President's Committee of Advisors on Science and Technology and the National Science and Technology Council. Led jointly by NSF and the Department of Education, this initiative should support research that yields timely findings and thoughtful plans for transferring lessons and influencing those responsible for math and science teaching and learning, K-16.

Prospects

In 1983, the same year that *A Nation at Risk* was published, the NSB Commission on Precollege Education in Mathematics, Science and Technology advised:

> "Our children are the most important asset of our country; they deserve at least the heritage that was passed to us . . . a level of mathematics, science and technology education that is the finest in the world, without sacrificing the American birthright of personal choice, equity and opportunity."

The health of science and engineering tomorrow depends on improved mathematics and science preparation of our students today. But we cannot delegate the responsibility of teaching and learning math and science solely to teachers and schools. They cannot work miracles by themselves. A balance must therefore be struck between individual and collective incentives and accountability.

The National Science Board asserts that scientists and engineers, and especially our colleges and universities throughout the U.S., must act on their responsibility to prepare and support teachers and students for the rigors of advanced learning and the 21st century workplace.

Equipping the next generation with these tools of work and citizenship will require a greater consensus than now exists among stakeholders on the content of K-16 teaching and learning.

As the NSB report shows, national strategies can help change the conditions of schooling. In 1999, implementing those strategies for excellence in education is nothing less than a national imperative.

DR. VERA C. RUBIN

Vera C. Rubin is an observational astronomer at the Department of Terrestrial Magnetism, Carnegie Institution of Washington. She has devoted her professional career to the study of motions of gas and stars in galaxies and motions of galaxies in the universe. Rubin's studies have played a significant role in uncovering previously unknown features of the universe, especially relating to dark matter.

Dr. Rubin is a graduate of Coolidge High School, Washington, D.C., Vassar College (BA), Cornell University (MA) and Georgetown University (PhD); George Gamow was her thesis advisor. She has honorary D. Sc. and D.H.L. degrees from numerous universities, including Harvard, Yale, Ohio State, and Michigan. She is a member of the US National Academy of Sciences, and the Pontifical Academy of Sciences. President Clinton awarded her the National Medal of Science in 1993, and nominated her to the National Science Board, 1996-2002. In 1996, she received the Gold Medal of the Royal Astronomical Society (London), the first woman so honored since Carolyn Herschel in 1828. She has been a Phi Beta Kappa Scholar, among many other Distinguished Visiting Professorships and science prizes, including the Dickson Prize in science from the Carnegie Mellon University, the first astronomer to do so, and the Weizmann Women & Science Award. In 1965, Dr. Rubin was the first woman permitted to observe at Palomar Observatory.

Rubin has been an enthusiastic lecturer in the US and abroad, including Chile, Europe, USSR, India, Japan, and China. She interacts with students extensively, from elementary grades through postdoctoral studies. When her children were attending DC public schools, she twice volunteer-taught a college level course in astronomy. She is active in supporting and enhancing the role of women in science.

In the Rubin household, science is a family affair. Dr. Robert Rubin, a mathematical physicist and Vera have 4 children, each with a PhD in science. David and Allan are geophysicists, Judy Young is an astronomer, and Karl is a mathematician.

HEARING OF THE COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

Why and How You Should Learn Math and Science
March 17, 1999

FOLLOW-UP QUESTIONS & ANSWERS

DR. VERA RUBIN
MEMBER, NATIONAL SCIENCE BOARD
Submitted April 7, 1999

How could the roles of teachers and administrators better complement one another such that they could synergistically strengthen K-12 mathematics and science learning? What are the current conflicts in the system?

Teachers and administrators share a commitment to strengthening K-12 math and science learning. Instruction, however, is embedded in a school day typically structured not to support in-depth teaching and learning. Teachers need time to prepare classroom lessons, as well as opportunities for professional development that improves their content knowledge. Teachers' access to information via resources persons outside one's home school is also dependent on connections to the Internet, an adequate number of computers, and available time during the school day. Administrators can help secure these instructional aids and mediate accountability demands to ensure that student performance becomes a true measure of effort and learning rather than threats and punishments for behavior over which teachers have little control. Many conflicts derive from poor communication, insufficient support for the professional needs of teachers, and requirements that emanate from outside the school and the district. According to a 1998 OECD report, a typical U.S. teacher spends more time in front of a classroom than teachers in other countries, but is paid less. This is a recipe for "conflicts in the system."

The report recently issued by the National Science Board calls for "meaningful accountability" for states, schools and school districts. What form of accountability measures do you think will be most effective?

Accountability must match classroom/school, district, and state-wide measures of performance to the content of instruction. If assessments are not aligned with frameworks, curricula, and materials as taught in the classroom, student learning will not be accurately gauged. National, state, district, and classroom assessments have different origins, so alignment is not easy. Misusing test scores as a gauge of the quality of teaching or learning can have punitive effects on all participants, especially if future resources hang in the balance. Coordinating topical coverage and sequence across all schools in a state would harmonize teaching and learning, and make accountability more meaningful. Some states recognize that accountability is double-edged, e.g., preparing for statewide tests that will measure school- and grade-level performance nevertheless saps time from classroom instruction. Balancing the need for external monitoring against teacher discretion to "reach" students with different learning styles, strengths, and weaknesses is a continuing challenge.

Regarding the TIMSS results, can you tell the committee whether those countries whose students scored well in math and science employ the types of teaching methods and curricula that, according to the NSB report, is the best way to impart understanding and knowledge? What can their success tell us about how to improve our own math and science education?

The chief factor in imparting understanding and knowledge of math and science is a well-prepared classroom teacher who has command of the content he or she is asked to cover. This finding is supported by TIMSS results. (a) A secondary analysis of TIMSS published in the May 1998 Educational Researcher suggests that no particular curriculum correlates with student performance. For example, of 29 countries with a national curriculum, in 7th and 8th grades, 14 outperformed the U.S. in math, while 15 showed no difference or were significantly lower. Of the 11 countries with no national curriculum, two were higher than the U.S., six the same, and three lower in performance. A national curriculum alone does not lead to higher student achievement. (b) As for teaching methods, the TIMSS video study of middle school mathematics instruction suggests that active, problem-solving-based interaction between teacher and student enhances understanding. Compared to classes in Japan and Germany, U.S. students are taught content two grades below their age peers, with less emphasis on deductive reasoning and more drill on concepts alone. Only a confident teacher steeped in the subject matter can bring content to life and connect classroom inquiry to real-world applications. Yet particular teaching practices are only one factor in high student learning, as observed in Japan. Broader cultural factors influence what students bring to the classroom, and their subsequent performance.

The report recommends "citizen advisory boards" that would review the education practices of their local school districts. How would such an advisory board differ from a school board? What would be the benefits derived from a citizen advisory board that a school board doesn't impart? How would the two entities interact with one another?

School boards are either elected or appointed. A citizen advisory board could be subsumed under a school board regardless of how it is constituted. The purpose is to increase informed participation by more community stakeholders who may or may not have children in the district. This process would include scientists and engineers with professional competence in mathematics and science. The citizen advisory board could function as a committee of the school board or, alternatively, be created independent of the district structure. In either case, the district leadership would welcome the review and input of parents, educators, and concerned citizens on the suitability of curriculum frameworks, instructional materials, and teaching methods.

Another recommendation of the report is that incentives be offered to students to "take tough courses or work hard." What types of incentives do you, or the NSB, believe effectively motivate today's students?

Students want to understand the connection between classroom skills and workplace requirements. They want to see the relevance of what they are being taught for later use in college and work. An effective means of demonstrating the connection is by presenting adults who use mathematics and/or science routinely in their work. That is why role models are so important. Parents often serve as models and motivators. When parents care about the quality of their children's schooling, student performance improves. Similarly, mentors help make aspirations attainable. They underscore the need for hard work. And they dramatize that high expectations coupled to rigorous coursework not only encourages learning, but also builds confidence in the student's ability to learn and solve problems through inquiry.

TESTIMONY
U.S. House of Representatives
Committee on Science
Hearing on
"Why and How You Should Students Learn Math and Science"
Wednesday, March 17, 1999

Rodger W. Bybee, Executive Director, Center for Science,
Mathematics, and Engineering Education, National Research Council
Joan Ferrini-Mundy, Associate Director, Center for Science,
Mathematics, and Engineering Education, National Research Council

The questions posed by the Committee on Science are a foundation for identifying the direction and organizing principles for mathematics and science education. The central questions can be stated as: Why should students learn mathematics and science? What mathematics and science should students learn? How should mathematics and science be taught? These questions are both timeless and timely. They are timeless because at some level the questions have been asked from the beginnings of education in this country; they are timely because the United States is entering a new century and the closing decades of this century have been a period of significant educational reform. The moment is opportune to set a direction and steer a steady course toward higher levels, and new formulations of mathematical and scientific literacy for all students.

To make sense of the task of improving mathematics and science education, it is essential to begin by rethinking and clarifying goals. This means asking the why questions before deciding what should be taught and how that content should be taught. The process of rethinking, discussing, and even debating these questions will help to achieve unity on the purposes of mathematics and science education.

As a social institution, education has the goals of developing to the degree possible the intellectual, ethical, and physical qualities of all students as individuals. Further, education has a goal of preparing students to exercise their rights, duties, and responsibilities as citizens. These goals apply to all students regardless of gender, race, ethnic origins, age, or abilities. Justification for teaching mathematics and science rests on the utility of mathematics and scientific knowledge to individuals in their work and responsibilities as citizens; the value of understanding mathematics and science to our cultural heritage; and the personal enrichment that mathematics and science can add to life.

We have been engaged in a great public dialogue, at local, state, and national levels, about the content and directions of school science and mathematics. To be clear, much of this dialogue originally centered on the role and contents of standards and assessments. The dialogue has progressed to the form and function of curriculum materials, instructional practices, and the importance of teacher preparation and professional development. We believe that these ongoing debates and conversations have the potential of achieving a unified view of an appropriate mathematics and science education for all students. So, as different and sometimes conflicting as the dialogue has been, it is fundamental for our democracy and the fact that primary responsibility for many educational decisions lies with state and local authorities.

WHERE ARE WE IN MATHEMATICS AND SCIENCE EDUCATIO

The Third International Mathematics and Science Study (TIMSS) has rightfully gained the public attention. The Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international comparison ever undertaken. During 1995 the study assessed the mathematical and scientific knowledge of a half-million students from 41 nations at three levels of schooling. In the United States those levels were 4th, 8th, and 12th grades. The achievement results of TIMSS are reported in three reports entitled *Pursuing Excellence*. Although this discussion will not describe the specific results of TIMSS, the results do form a baseline of achievement and an answer to the question – Where are we in mathematics and science education? The brief answer to this question is that we are not doing very well; we need to improve.

The most encouraging results were at the fourth grade and in science. The U.S. was tied for second among TIMSS countries on the overall science score. On mathematics our students were somewhat above average, at fourth grade. What about eighth grade? In science our students were slightly above the international average. In mathematics the U.S. scored below the international mean in almost every area. Twelfth-grade mathematics and science achievement was, to say the least, disappointing. On both mathematics and science our students were among the lowest scoring countries. This was also true for the achievement of advanced students. Where are we? In international comparisons we begin near the top and with time slowly drop to a point near the bottom. This is not a position that the U.S. public should tolerate. The questions become – What can we learn from TIMSS? And what is an appropriate response for the U.S. educational system? The full story of TIMSS is detailed in numerous publications.

We note several points about TIMSS. First, TIMSS is a collection of evidence not only about achievement, but about different approaches to teaching (e.g., the video study), and the role, types, and influences of curriculum materials and teacher backgrounds. The fact that discussions of TIMSS have a foundation in evidence —data about achievement and school programs and practices— is both significant for the power of these international studies and symbolic for the theme of our discussion. One reason the TIMSS reports have enjoyed so much public attention may be our scientific view that data are important to understanding the similarities and differences of mathematics and science education in other countries. From our perspective, inherent in the public discussions and educational debates about education is the need for citizens to develop the abilities to reason using data. This is an educational aim shared by mathematics and science education.

Viewing TIMSS results as the baseline from which American science and mathematics education must develop has very real potential and some meaningful consequences. The potential lies in what can be learned from cross cultural comparisons, the data-based approach to understanding the influences on student achievement, and the role of culture on educational systems. The extensive use of TIMSS, does, however, have some consequences that we might expect. First, and perhaps foremost, is a paradox. In using TIMSS findings as the foundation, we are at least using the results in a unified national perspective. Whether we explicitly recognize it or not, comparing the United States as one nation to other nations conflicts with the fact that we really have 50 states and some 15,000 school districts making individual decisions about standards, curriculum instruction, and assessment. To be clear, states and local jurisdictions exercise the Constitutional privilege of deciding on their educational priorities and approaches to mathematics and science education. This situation could engage discussions about a core curriculum for the nation. Or, the use of TIMSS for guidance could lead to deeper consideration about data gathering processes that are customized to local use. Debates, for example in California, over mathematics and science would be an example and early indication of what could develop on a larger scale. On the other hand, there could emerge a consensus among other states about the essential content of the mathematics and science curriculum, effective approaches to teaching, and the need for continuous professional development of mathematics and science teachers. This is an example of how developing a national perspective for curriculum, instruction, and assessment could build naturally from the school districts.

We should note a second caution, also based in TIMSS. For methodological, educational, and economic reasons, the TIMSS achievement tests were based on a particular framework to the mathematical and science content. These frameworks and the TIMSS released items are viewed increasingly as "standards and assessment," leading to assumptions that these concepts and skills should be the content of the curriculum, and even implying a "TIMSS" approach to teaching. Here is the second caution: TIMSS was designed to measure the state of science and mathematics education internationally by looking at student achievement, curriculum, at teaching, and at school and teacher variables. TIMSS provides us with an incomparably rich and extensive set of data to be interpreted, re-analyzed, and discussed in search of better understanding the state of science and mathematics education. Granted, in order to test achievement, an assessment framework was designed, a framework that needed to meet methodological, education, economic, and even political constraints. But, an assessment framework is not a set of standards. And, in gathering videotape evidence about teaching, coding and analysis schemes were designed to provide description – but these do not provide a set of prescriptions about how to teach.

Another caution about TIMSS. In our zest for simple solutions we already are seeing examples of importing curriculum frameworks, textbooks, tests, and other educational ideas from countries where students achieved at levels higher than in the United States. Along with providing a general understanding of cultural differences, the TIMSS studies have shown that there is a distinct cultural character in the curriculum and teaching in other countries. Simply translating and importing another country's curriculum is fraught with unintended consequences that would, we predict, complicate the state of mathematics and science education more than it would help.

Finally, we note that what has captured the public's attention is TIMSS achievement results. Although it is important, even essential to make changes in curriculum content, i.e., it should not be an "inch wide and an inch deep," we should recognize that a limiting factor of student achievement may be the teacher's understanding of mathematics and science, especially as this understanding is combined with pedagogical strategies. The implication seems to point directly to teacher preparation and professional development.

WHERE SHOULD WE BE HEADED IN MATHEMATICS AND SCIENCE EDUCATION?

Many have made eloquent arguments over the years about the importance of quantitative and scientific literacy for the society. Jefferson observed that an informed citizenry is "the only safe repository for the preservation of liberty." The content standards movement, initiated by the National Council of Teachers of Mathematics in 1989 with its *Curriculum and Evaluation Standards for School Mathematics*, and followed in science with the American Association for the Advancement of Science *Benchmarks for Science Literacy* and the National Research Council's *National Science Education Standards*, holds as its central theme the importance of science and mathematics **for all** students. Among the many compelling arguments for this view, the one advanced in 1983 in *A Nation at Risk* continues to be most persuasive: "The twin goals of equity and high quality schooling have profound and practical meaning for our economy and society, and we cannot permit one to yield to the other either in principle or in practice... Our goal must be to develop the talents of all to their fullest." Sadly, 16 years beyond that report, the nation still cannot claim to have made substantial gains.

Of course, even if we can achieve consensus on the principle that all citizens have a "civil right" to high quality education in science and mathematics (broadening Robert Moses's view about algebra), we still face another age-old question in education: what *is* the mathematics and science that all citizens should know? The debates about what knowledge is appropriate have ranged over decades and today are ranging over a breadth of constituencies, including scientists, educators, parents, and even the popular press. Of course there is not one right answer to "what should students know and be able to do." There are only well reasoned proposals, grounded in research evidence, the wisdom of teaching practice, the history and future of the disciplines, and in speculation about what will be important in the future.

In science and mathematics, when various groups attempt to describe the desired knowledge base, they find themselves considering proposals for:

1. what *content* students should know (e.g., should they know what a polar coordinate representational system is? Should they know that plant cells contain chloroplasts, the site of photosynthesis;
2. what *procedures* students should be able to perform (e.g., should they be able to do long division by hand with 3-digit divisors? Should they be able to use technology improve data collection and communications;
3. what *thinking processes* should students develop (should they be able to reason deductively? Should they be able to formulate and revise scientific explanations and models using logic and evidence?

Over the past decades, it seems that much of the debate and disagreement about the goals of school mathematics and science have centered on the content and procedures that students should know and be able to do. For example, should there be more statistics and less trigonometry? Must students learn the binomial theorem? We propose that the more productive place to center these discussions might be on reasoning and the critical thinking processes that students should develop over their twelve years of schooling. They need these abilities in order to be the productive and fulfilled citizens, savvy consumers, and productive contributors to the economy. And mathematics and science education can provide excellent opportunities to develop these abilities.

Let us be clear: there is a body of basic content and procedural knowledge that will always be central in K-12 mathematics and science education. On the day (15 March 1999) we were preparing this testimony, USA Today reported that "just 32% of employers who hire new public school graduates think the grads have the skills they need." The areas under review included, among other areas, basic math and computer skills. Lest we be misunderstood, we underscore the importance of all students learning basic skills. Early in the 21st century, employers should report that all graduates have the skills needed for entry level jobs. But, with changing technologies for teaching, for learning, and for living, these lists of specific content and procedural knowledge should be expected to evolve and change. Professionals in the field- mathematicians, scientists, educators, teachers, users of science and mathematics, prospective employers – are best positioned and most expert to make the judgments, over time, about the content and procedural knowledge.

We propose here to focus on processes, and try to build an argument that would open up thinking to a public debate and focus that moves slightly away from the content/procedure battles. Consider the following, interesting observation "Modern high performance work involves problems that require sophisticated reasoning and practice, but only elementary mathematical skills. In contrast, the mathematics that students study to prepare for college requires advanced skills with abstract concepts deployed in simple (and simplistic) problem situations. (Steen & Forman, 19XX) We cannot hope to untangle this dilemma in this forum, but it suggests the utility of focusing on what science and mathematics education may bring to students' "ways of thinking" and "habits of mind." It is in science and mathematics classrooms that students can learn to reason, to communicate parsimoniously and unambiguously, to assess claims, detect fallacies, evaluate risks, and analyze evidence. These certainly might qualify as the skills of "sophisticated reasoning and practice."

To be more specific, consider what kinds of understanding and thinking are involved in evaluating risks – say risks of getting cancer? being delayed in travel because of weather? If one unpacks the notion of "evaluating risks", it might be clear that knowing the difference between: correlation and causation, an assumption and a conclusion, a representative sample and a biased sample, using evidence versus opinion as the basis for decisions, or probability and certainty all might be important in understanding risks. These are ways of thinking and elements of content that can and should be learned in science and mathematics classrooms.

The forthcoming revision of the NCTM Standards, *Principles and Standards for School Mathematics* (NCTM, 1998) emphasizes five process areas: problem solving, communication, connections, reasoning and proof, and representations. Likewise, the *National Science Education Standards* (NRC, 1996) emphasizes science as inquiry which includes among other things using evidence and knowledge to formulate a scientific explanation, understanding and evaluating alternative explanations, and communicating the results of a scientific investigation.

Our basic stance is that, although content and procedures are important, in fact essential, they are the context in which students will learn to think and reason, the more productive focus in this conversation about mathematical and scientific literacy for all is on the value added of reasoning and critical thinking that must be developed in the citizenry.

HOW DO WE MOVE IN THESE DIRECTIONS?

In this part of the discussion we take as axiomatic the commitment to high quality mathematics and science education for all. Certainly many in the professional community that carry out the day to day work of educating our children in science and mathematics seem to hold this commitment and are working diligently to find the appropriate curricula, assessments, and teaching methodologies to enact this notion. And, documents such as standards – statements of goals established by the profession—are a reasonable starting point for beginning conversations about the substance of what will go on in schools. With the ongoing revisions that the mathematics community has undertaken for its standards, which involves a wide-ranging conversation among all interested components of the system, and the planned revisions forthcoming in science, states and districts are able to work from these national documents to develop the kinds of goals and frameworks that fit their unique contexts.

We certainly support the need to improve science, technology, and mathematics education. Although not unusual or revolutionary, we can suggest some initiative that holds promise of improving student attainment. The first three center on teachers and teaching.

- Teachers are the single most valuable resource in the highly complex educational system. They can also be a limiting factor in the attainment of students' mathematics and scientific understanding and abilities. So, we must provide support for the mathematics and science preparation of teachers and for their continuing professional development.

- Teachers need curriculum materials that incorporate our best understanding of what students should learn and how they can most effectively learn science, technology, and mathematics. The National Science Foundation has provided leadership in such designs for mathematics programs and while this must continue, there is a clear need for new science and technology programs.
- Teachers need support from school administrators and the public for their work and effort required to help student attain higher levels of achievement in mathematics and science.

Finally the notion of systemic change as offered by Smith and O'Day is, in our view, still appropriate as a way to conceptualize the complexity of the kind of educational improvement needed as we enter the 21st century. We clearly have a long way to go, and national attention to the TIMSS findings, devices such as standards, frameworks, and even very heated debates about the appropriate direction for school mathematics and science, all are elements of the democratic process. Only by maintaining focus and commitment to creating well reasoned proposals for the content, procedures, and ways of thinking that should be addressed in school, and by working to align and enable the elements of the educational system in support of such proposals, can we remain hopeful of making progress on these most enduring educational challenges.

Programs and resources for the continuing improvement of mathematics and science education should include support for the ongoing learning of present and prospective teachers, for curriculum materials to be used both with teachers and with K-12 students, for research and evaluation of efforts to improve mathematics and science education, for the development of standards, frameworks and assessments to guide local practices.

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Rodger W. Bybee

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Rodger W. Bybee is Executive Director of the Center for Science, Mathematics, and Engineering Education (CSMEE) at the National Research Council, Washington, D.C. Between 1992 and 1995, he participated in the development of the *National Science Education Standards*, and from 1993-1995 chaired the content working group of that project.

Prior to this appointment, he served as associate director of the Biological Sciences Curriculum Study (BSCS). Dr. Bybee was principal investigator for several National Science Foundation (NSF) programs including an elementary school program entitled *Science for Life and Living*, a middle school program entitled *Middle School Science and Technology*, a high school program entitled *Biological Sciences: A Human Approach*, and the college program, *Biological Perspectives*. His work at BSCS also has included serving as principal investigator for programs to develop curriculum frameworks for teaching about the history and nature of science and technology and for biology education at high schools, community colleges, and four-year colleges.

From 1972-1985, Dr. Bybee was professor of Education at Carleton College in Northfield, Minnesota. He received his Ph.D. in science education and psychology from New York University. His B.A. and M.A. are from the University of Northern Colorado with majors in both biology and fine arts and a minor in earth science. He has taught science at the elementary, junior, senior high school, and college levels. Dr. Bybee has been active in education for more than thirty years. Throughout his career, Dr. Bybee has written widely, publishing in both education and psychology. He is co-author of a leading textbook entitled *Teaching Secondary School Science: Strategies for Developing Scientific Literacy; Reforming Science Education: Social Perspectives and Personal Reflections* was published in 1993. His most recent book is *Achieving Scientific Literacy: From Purposes to Practices.* Over the years, he has received awards for Leader of American Education and Outstanding Educator in America, and in 1979 was Outstanding Science Educator of the year. In 1989, he was recognized as one of the 100 outstanding alumni in the history of the University of Northern Colorado. Dr. Bybee's biography has been included in the Golden Anniversary 50th Edition of *Who's Who in America*.

Dr. Bybee is married to Patricia Bybee; they reside in Frisco, Colorado and Washington, D.C. An accomplished triathelete, he was ranked 2nd and 3rd in Colorado in his age group in 1991 and 1992, respectively.

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Joan Ferrini-Mundy is Associate Executive Director of the Center for Science, Mathematics, and Engineering Education and Director, Mathematical Sciences Education Board, at the National Research Council. She is on leave from her position as a professor of mathematics at the University of New Hampshire, where she joined the faculty in 1983. She holds a Ph.D. in mathematics education from the University of New Hampshire. Dr. Ferrini-Mundy taught mathematics at Mount Holyoke College in 1982-83, where she co-founded the SummerMath for Teachers program. She was the Principal Investigator for NCTM's Recognizing and Recording Reform in Mathematics Education (R^3M) project. She served as a visiting scientist at the National Science Foundation 1989-91. She chaired the NCTM's Research Advisory Committee, was a member of the NCTM Board of Directors, and served on the Mathematical Sciences Education Board. Dr. Ferrini-Mundy has chaired the AERA Special Interest Group for Research in Mathematics Education. Her research interests are in calculus learning and reform in mathematics education, K-14. Currently she chairs the Writing Group for Standards 2000, the revision of the NCTM Standards.

updated 3/99

NATIONAL RESEARCH COUNCIL
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17 March 1999

F. James Sensenbrenner, Jr.
Chairman
U. S. House of Representatives
Committee on Science
Suite 2320 Rayburn House Office Building
Washington, DC 20515-6301

Dear Chairman Sensenbrenner:

Attached is a summary of current federal grants and awards, which includes originating agency, project description, and funded amount for the Center for Science, Mathematics, and Engineering Education.

Sincerely,

Rodger W. Bybee
Executive Director

Attachment

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations.

Summary of Current Federal Grants and Awards
Center for Science, Mathematics, and Engineering Education

Sponsor	Project Description	Funded Amount
National Aeronautics and Space Administration	NASA Administrator's Fellows	$350,000
National Aeronautics and Space Administration	Understanding and Implementing the National Science Education Standards: An Addenda Series	$300,000
National Science Foundation	Providing Leadership for Standards-Based Reform in Mathematics and Science Education	$4,026,000
National Science Foundation	Developing a Guide for Designing Mathematics and Science Curriculum Programs	$137,000
National Science Foundation	Improving Teacher Preparation in Science, Mathematics, Engineering and Technology	$1,275,000
National Science Foundation	Mathematics Learning Study: Helping All Children Toward Success in Mathematics Learning	$1,580,300
U.S. Department of Education	Mathematics and Science Around the World: Continuing to Learn from TIMSS	$650,000
U.S. Department of Education	National Convocation on Mathematics Education in the Middle Grades	$275,720
Department of Health and Human Services/ National Institutes of Health	State Leadership Institute on Standards-Based Mathematics and Science Education	$30,000
SUBTOTAL FEDERAL - CSMEE		**$8,624,020**

3/16/99

RESPONSES TO FOLLOW UP QUESTIONS

Dr. Rodger Bybee
Dr. Joan Ferrini-Mundy
National Research Council
July 16, 1999

1. **Since we know that intellectual development follows from the learning of math and science, should we emphasize these subjects in the earliest years of learning?**

It is crucial to emphasize mathematics and science from the earliest years of learning. Very young children are naturally inclined to think and behave in mathematical ways. They observe and are attracted to patterns; they make distinctions among colors, shapes, and objects; they sort and classify; they discriminate among small numbers of objects; and they count. Activities and learning opportunities in the home and in early childcare settings can build easily on, and expand, these inclinations in ways that provide a strong foundation for formal schooling. At these early ages children tend to enjoy mathematical activities that extend their experiences and that draw naturally on the contexts in which they live.

As for early scientific knowledge and ways of thinking, children are naturally curious about their environment. Their curiosity leads them to physical and mental interaction that naturally supports development of ideas about the world, for instance spatial relations, relative time, and cause and effect. Such ideas form the basis for reasoning and logic in mathematics and science, as well as in other subjects, and help students form explanations about their encounters with the world in general.

2. **Is it necessary, or advantageous, to expose students to the complexities of math and science in the early years to attain the benefits, or are more simplistic demonstrations sufficient to introduce them to the underlying principles?**

It is important in the early years for children to have opportunities to acquire a strong foundation in several areas of mathematics and science. These subjects are complex and cumulative, and in order to reach deep understanding across a range of areas within each by the end of secondary school, curricular trajectories that are based on a strong early foundation need to be developed.

In mathematics, children are naturally inclined to count, perform simple computations about interesting problems in their worlds, find and build patterns, and sort and categorize. Quality mathematical experiences for young children will be most possible in environments that are rich in language, encourage children's own thinking, and nurture children's explorations. The mathematical ideas that are accessible to children in the early years are actually quite complex. Any first grade teacher who is helping children transition from "counting all" to "counting on from the larger number" in performing simple additions will acknowledge that, for children, the mathematics of early number is rich and complicated. The important point is that this early instruction should be meaningful for children, should build on what they know, and should only emphasize terminology that is useful and procedures that are understood. In addition, young children need experiences in mathematics beyond number and arithmetic, to include early concepts in geometry about shape, early algebraic ideas such as pattern and variable, and experience with measurement and recording data. These areas of mathematics are fundamental, but not easy to teach and learn.

In science, it is certainly advantageous to involve students in diverse experiences that establish the basis for understanding the concepts of science. Children's natural curiosity is evident in their ever-present questions of "Why" " How" and "What if." In formal settings such as school classrooms, careful structuring of experiences can lead to the eventual development of scientific ideas such as the particle nature of matter, cells as basic building blocks of living organisms, photosynthesis as a life process in green plants, conservation of matter and energy, the forces and dynamics that shape Earth, and the motions of Earth in the solar system. Too often however, there is a rush to provide technical vocabulary before students have developed the basic understanding for such important, but abstract, scientific ideas.

3. Within the context of today's classrooms, what are your suggestions for how to apply what we know about learning science and mathematics?

Research in teaching and learning has provided a substantial base of information upon which teachers, curriculum developers, and policy makers might draw to improve school science and mathematics education. There is much guidance available about the conditions under which children can effectively learn mathematical and scientific concepts, about the need for active engagement by students, about the need for teachers to build upon student understandings and about the importance of helping students connect ideas.

Unfortunately, this research base has not effectively made its way into practice. Teacher education programs, both preservice and inservice, draw upon and acquaint teachers with ideas from research. Likewise, curriculum materials could be developed with more consideration of what is known about children's learning.

In brief, the ways and means of applying what we know about learning science and mathematics center on establishing clear goals for the subjects, developing instructional materials that apply principles of learning to the designing of those materials, assuring appropriate implementation of the materials through professional development of teachers, and formally, achieving public support for the aforementioned materials and professional development.

4. Based on the consensus that we should develop and foster math and science skills in our children, what are the short-term and long-term implications for current school science and mathematics programs?

Higher expectations about what students should know and be able to do in science and mathematics, as well as who should have opportunities to learn this science and mathematics content, are critical. Documents such as national standards offer well-reasoned proposals for what students should know. The emphasis of standards documents on all students also is critical. The short-term implications involve the continuing development of high quality curricula that will provide opportunities to learn significant science and mathematics content. The longer-term challenge is the overhaul of the teacher education infrastructure, both preservice and inservice, that is necessary to support teachers to help all students move in these new and ambitious directions.

5. **What aspects of teaching science as a mode of inquiry and mathematics as a problem solving exercise may be beneficial to students beyond their coursework?**

The clearest and most direct way to respond to this question is by listing in detail the modes of inquiry and emphasizing the specific underlying emphasis on critical thinking and reasoning that pervade inquiry as described in the National Research Council's (NRC) *National Science Education Standards*. As you review these following standards note the thinking that is either explicitly stated by words such as analyze, interpret and think critically and logically; or implied in processes such as identify, question, design (scientific investigation), use appropriate techniques, develop descriptions using evidence, recognize alternative explanations, and communicate procedure and explanations.

Content Standard A: Science as Inquiry

As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific literacy
  - identify questions that can be answered through scientific investigations
  - design and conduct a scientific investigation
  - use appropriate tools and techniques to gather, analyze, and interpret data
  - develop descriptions, explanations, predictions, and models using evidence
  - think critically and logically to make the relationships between evidence and explanations
  - recognize and analyze alternative explanations and predictions
  - communicate scientific procedures and explanations
  - use mathematics in all aspects of scientific inquiry

National Science Education Standards, National Research Council, 1995, pp. 175-176

In mathematics, the problem solving and reasoning standards that have been provided by the National Council of Teachers of Mathematics (NCTM) offer a set of expectations, appropriate from pre-kindergarten through grade 12. Consider how elements of these standards— represent, abstract, generalize, investigate—can apply in contexts beyond mathematics.

> Mathematics instructional programs should focus on solving problems as part of understanding mathematics so that all students—
>
> - build new mathematical knowledge through their work with problems;
> - develop a disposition to formulate, represent, abstract, and generalize in situations within and outside mathematics;
> - apply a wide variety of strategies to solve problem and adapt the strategies to new situations;
> - monitor and reflect on their mathematical thinking in solving problems.
>
> Mathematics instructional programs should focus on learning to reason and construct proofs as part of understanding mathematics so that all students—
>
> - recognize reasoning and proof as essential and powerful parts of mathematics;
> - make and investigate mathematical conjectures;
> - develop and evaluate mathematical arguments and proofs;
> - select and use various type of reasoning and methods of proof as appropriate.
>
> *Principles and Standards for School Mathematics:Discussion Draft*, 1998, p. 49.

6. **What are the implications for support from federal agencies, such as the NSF, U.S. DOEd, NASA, NIH?**

Appropriate support from federal agencies falls into several domains. First, there is a need for increased support for research about student learning, and transfer of skills and thinking from mathematics and science to other general areas. Second, there is a need for support for the design and development of instructional materials that exemplify what is known about teaching and learning and what are commonly understood to be basic mathematical and scientific concepts and processes. Third, support for studies about teaching and teacher learning, for the professional development of teachers (preservice as well as inservice), and the complementary task of implementing instructional materials in school science and mathematics programs, is needed. Finally, there is a very real need to coordinate these efforts among the federal agencies. A combined and coordinated effort could make a significant difference in the primary goal – student learning of science and mathematics.

Questions from Democratic Members

1. **What kinds of federal education programs could make a significant contribution to assisting state and local school systems with the implementation of science and math standards?**

Federal education programs of three different types would be useful to the implementation of science and mathematics standards. Most importantly, programs designed to support and improve the teacher education infrastructure are critical. Currently, preservice teacher education approaches are tremendously varied and not necessarily grounded in any particular theoretical or research-based perspectives. Nor are they necessarily tailored to prepare teachers to use their content knowledge in teaching. Further, the system for the continuing education of teachers is fragmented across higher education, local school districts, commercial textbook publishers, independent contractors, and others. There are not widely used frameworks to guide any sort of development in teacher learning over the career, or to help providers of inservice education share and build upon one another's work. The concept of "curriculum for teacher education" is underdeveloped in this country. We tend to work on old and overly generalized assumptions about effective teacher education (summer institutes are good, more content knowledge is the best emphasis), and lack the research that might support different conceptualizations of where and how teachers learn (including from their own practice as teachers.) Further, there is very little systemic research that examines the effectiveness of various teacher education approaches upon teacher learning, or ultimately, upon student learning. And, until the nation can be much more systematic and effective in the preparation and continuing education of teachers, there is little chance that teachers will have the capacity and knowledge to implement the ideas put forth in standards in a comprehensive way that improves student learning.

Secondly, continuing support is necessary for the development of standards-based curriculum and assessment materials, coupled with ongoing work in teacher education. Until school district decision-makers, and teachers, have access to a wide enough range of interesting and useful curricula, major shifts in the directions of standards are unlikely to occur. Evaluation and research that examines the utilization of instructional materials also is necessary.

Finally, the continued support of efforts at systemic change, including the alignment of curricula, pedagogy, and assessments, and with support and agreement among all elements of the system, including parents, school decisions makers, and policy makers, there is a chance that significant improvements in science and mathematics education can take effect.

2. **Relative to impact on implementation of standards, are there particularly good, or bad, examples of federal programs? Are the federal programs effectively coordinated?**

In mathematics there are several programs of instructional materials, many of them federally funded, that have been quite highly rated relative to NCTM standards and American Association for the Advancement of Science (AAAS) *Benchmarks*. (See the review by the

AAAS Project 2061.) According to reviews, instructional materials in science have not realized the comparable strength of mathematics programs. However, standards and benchmarks for science have not been available for enough time to make a fair evaluation. And, many evaluations are based primarily on analysis of the content of the materials, rather than on the effects and uses of the materials in classrooms.

Concerning another level of "programs", the National Science Foundation's efforts on systemic initiatives (e.g., state, local, urban, and rural) hold great promise, but the next phase should address issues of implementation of instructional materials and professional development both based on national and state standards. In brief, the idea of a systemic approach to improve mathematics and science education is excellent. Systemic reform requires time (more like decades rather than years), there must be continuous efforts that change and adapt as the educational system changes, and resources must be included to allow for study of the system.

In general, federal programs to further the improvement of mathematics and science education could benefit from increased coordination and more consistent perspectives and messages. Such coordination is difficult unless the agencies involved are able to hire adequate numbers of senior program staff with deep expertise in science and mathematics education.

3. **A difficult aspect of implementing the math and science education standards is translating them into the materials needed for classroom instruction.**

This observation is accurate. This process is particularly difficult when one reviews national, state, and local standards and considers issues such as the time, financial support, and expertise to develop and implement materials at the local level. Based on the issues presented in such reviews and experiences, it seems appropriate to support development of new materials by professional groups who do this. Groups of university-based experts, as well as organizations specializing in curriculum development (e.g., the Biological Sciences Curriculum Study (BSCS), Education Development Center (EDC), Lawrence Hall of Science (LHS), National Science Resources Center (NSRC), and TERC. In addition, there is a need to attend to the "pipeline" of professionals who have expertise and inclination to pursue instructional materials development.

4. **What is the availability of textbooks and other educational materials that conform to the math and science standards?**

Deciding whether textbooks or materials "conform" to mathematics and science standards is very complicated. As soon as the 1989 NCTM standards were released, the tables of contents of new editions of commercial textbooks immediately included the topics addressed by standards. The same is true for science textbooks released after 1996 when the NRC standards were published. However, standards not only promote attention to specific content areas, they emphasize approaches to that content (such as emphasis on making meaning and learning with understanding), pedagogical approaches, and important thinking processes (problem solving, reasoning, inquiry, etc.). Gauging whether instructional materials are consistent with standards is almost impossible apart from understanding the context in which teachers and students use the materials. Nonetheless, a number of organizations and agencies (U.S. DOEd, AAAS, NRC, etc.)

have attempted to provide materials that either make judgments about alignment or offer guidance to decision makers for how to judge alignment and quality.

Given all this, the general finding seems to be that there are few materials that are found to conform well to standards. Many of those that do tend to be innovative, developed with federal funds (e.g., NSF, NASA, NIH), and unfortunately, these programs are not necessarily widely adopted and implemented.

5. **Is there any mechanism through which educational materials, which are claimed to conform to the standards, are formally reviewed and tested for the benefit of school administrators and teachers, so that they can select the best available materials for use in the classroom?**

As indicated in the previous response, there are now processes for evaluating the content of instructional materials for their alignment with standards. However, a major flaw in these processes is their failure to include a means of measuring the context in which materials will be used. Variable such as: teacher readiness, teacher content knowledge, community expectations, relationship of materials to high stakes state or local assessments, experience of children, administrative support, available materials and resources, etc. all are likely to be critical to the effective implementation of instruction materials. So, materials that are "standards-based" can be used in very "non-standards-based" ways, and conversely.

Several groups (e.g., DOEd, AAAS) are reviewing instructional materials against standards. These reviews will be quite helpful to the education community. In addition, with support from a private foundation (Woodruff) the NRC will complete and disseminate a guide for the review and selection of materials for science programs. That guide should be available early fall of 1999.

6. **What has been the record of success in translating the finding from cognitive science into practical materials and pedagogical approaches for use in classroom instruction in science and math?**

The short answer is—not much. Although this sounds like an idea that makes sense, in actuality the content and pedagogy of school programs is dominated by the requirements of state frameworks and criteria for adoption of instructional materials. Very little attention is paid to the findings from cognitive science. Recent publication of the NRC report, *How People Learn*, may have some influence on instructional materials, but the probability of this is low in spite of the quality of the NRC report.

7. **In general, are most new educational materials being developed for science and math instruction consistent with what is now known about childhood cognitive development? Is collaboration usual between the materials developers and researchers in psychology?**

Most mathematics and science materials are developed with a general recognition of the cognitive development of children. This is largely based on the emphasis given Jean Paiget's views popularized in the 1960s and 1970s. Actual collaboration between curriculum developers and psychologists is rare. However, review of instructional materials and input by cognitive psychologists is quite common.

8. A recent RAND report on educational technology commissioned by the Office of Science and Technology Policy recommends greater federal investment in pre-competitive multimedia educational software R&D to help overcome market disincentives faced by software vendors that has resulted in a deficiency in content-based educational software. How would you characterize the quality and availability of educational software and other technology-based educational materials?

- **Is there a need for a systematic process for assessment of educational materials and a central clearinghouse for the distribution of the most effective materials?**
- **Is more effort needed on dissemination of information about best teaching practices?**

Relative to the first point, there may be a need for systematic assessment of materials, particularly multimedia educational software, and a central clearinghouse for distribution. One must guard against any approach that suggests a national curriculum, however, and be realistic about the difficulties in determining what is "most effective." In practice, a "Consumer Reports" type resource that looks at instructional materials might be very useful. Responding to the second point is easy – yes, the process, especially an effective process, that reaches teachers presents a challenge.

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TESTIMONY FOR THE HOUSE SCIENCE COMMITTEE, MARCH 17, 1999

AMY KASLOW, SENIOR FELLOW, COUNCIL ON COMPETITIVENESS

Never before has the appearance of working America been so deceiving. Payrolls have hit record highs and the unemployment rate is the lowest it's been in decades. But the reality behind the numbers is troubling.

An acute skills shortage in every part of the country threatens the foundation of American competitiveness. While debate rages on about the K-12 dilemma, the inadequacies of American schooling are inescapable in the American workplace, where too few people have learned how to learn.

By that I mean too many new graduates, would-be workers, and existing employees cannot read or do simple math, two essentials for adapting to new tasks and meeting market demands. Remedial education has become the norm, not the exception. And that's before any training can occur.

The "haves" and the "have nots," or the widening skills and wage gaps among US workers, have taken on more complicated meanings. There is a premium on new entrants who possess the skills necessary to land positions. There's an equally high value put on incumbent workers who are savvy enough to upgrade their skills for ever-changing demands. The flip side, of course, is the penalty for those who fail to measure up.

In our two-year search for best practices that help bridge the gaps, the Council on Competitiveness drew upon experts and practitioners in the training field, and we hosted many meetings in Washington, where decisions about workforce training once originated. But recognizing that problems and solutions are locally based, our research team moved around and covered a wide swath of the country.

We listened to people. We met with CEOs and managers from the modest start-up firm to the multinational, who typically reject the vast majority of job applicants -- upward of eighty percent -- because they fail to meet the most rudimentary standards. We logged many hours on the factory floor, meeting with organized labor and non-union workers, some of whom shared their fears of further training and others their triumphs in re-tooling their skills. We sought out the most cutting-edge educators, including community colleges, vocational training centers, and corporate universities, where workforce preparedness is big business. We captured some of the most dynamic work at municipal offices where professionals are dedicated to matching skills with employer needs.

Our findings are by no means exhaustive, but they are strongly indicative of the depth and scope of a pressing national concern. We fully appreciate the need for strong analysis, backed by sound data. But we've tried to put a human face on a challenge that is urgent, and too often viewed as an abstraction.

The problems and potential solutions are not limited to any particular place or time. Nor are they restricted to one level of the workforce, or to one specific business. The issues are very real across the spectrum.

In the Midwest for example, business has been booming and skilled labor is nowhere to be found. A major employer in Milwaukee, the automation firm Allen-Bradley, is working against time because within ten years, eighty percent of its employees will retire. The greying of the national workforce has produced a massive requirement to replace a generation of skilled wage earners that will reach retirement age by 2005. To avoid their own contraction, companies like Allen-Bradley have been scouring both local and distant schools to find qualified new entrants. This fixation on meeting current labor needs has become management's most absorbing responsibility.

In parts of the Sun Belt, populations are growing at staggering rates. US West communications has been unable to meet service demands in Arizona, Colorado, and Nevada, where many newly-built homes have no access to telephone service. With an infrastructure originally designed to meet the needs of a small, rural population, US West cannot keep pace with today's construction rate. Companies like US West, ever-more advanced technologically, are hard-pressed to train, hire and retain a whole range of workers in one of the nation's most competitive industries.

Nowhere is the bidding war for skilled technicians hotter than in California's Silicon Valley, where some eighty percent of the jobs require specialized learning and basic technical knowledge. Skills are particularly prized because of the constant churning among existing workers who jump to new job opportunities. Local community colleges are among the best-equipped schools to tailor training programs needed to transition workers from one job to the next. Whether the courses are conducted on-site, at corporate headquarters and plants, offered at the school campus, or available on-line, the learning process is geared toward immediate and practical application in the workplace. The most progressive, and the most successful firms use this "just-in-time" learning.

The scramble for workers is just as intense in the entertainment industry, where the skills requirements are less rigorous than the tech industry, but just as tough to come by. Service sectors in areas like Orlando, Florida must satisfy massive and immediate hiring needs. Rapid turnover only exacerbates problems for Walt Disney World Company and Universal Studios, the area's two major employers drawing from the same shrinking pool of workers. Like other areas across the country, Orlando's supplier firms and other small businesses that service or have grown as a result of the big companies' expansion, are losing the fight for the very same workers.

Complicating these developments are a set of trends that will only intensify in every sector of the economy:

* Information technology is a defining feature of the American workplace, adding computer literacy to the list of basic skill requirements and generating even more demand for workers.

* Global competition is not just a challenge from overseas, it's right in our backyard. Well-trained foreign workers abroad lure increasing numbers of American companies to set up shop outside US borders. But foreign workers who are "imported" to the US underscore just how essential skills are to worker marketability. And they reveal how the ill-equipped American worker is at risk of being cast aside for the international with know-how.

* Over the next five years welfare reform will move several million mostly unskilled Americans from public assistance to entry-level jobs. Without adequate preparation, they will only add to the ranks of the un-employable.

You asked for a brief outline of the problems. The Council's report, "Winning the Skills Race," which I'd like to submit for the record, draws upon a much richer set of examples than I was able to mention here. But more to the point, we have documented innovative, collaborative efforts -- between employers, workers, educators, and government -- that have boosted the skills, and ultimately the income, of American workers. When you are ready to consider solutions, we strongly recommend that you take a look at these collaborations. They very clearly lead by example.

Thank you.

AMY KASLOW

Amy Kaslow is an independent print and broadcast journalist reporting on international economic developments.

Ms. Kaslow is a regular contributor to Marketplace, the top business and economic program on National Public Radio. Her series span a broad range of topics, such as the post-war reconstruction of Bosnia, funding the arts in Russia, the price of NATO expansion, Asia's financial crises, the volatile emerging markets, and the advent of the Euro.

Since May, 1996, Kaslow has been a senior fellow at the Council on Competitiveness in Washington, D.C. where her focus has been on economics and employment. She is author of "Winning the Skills Race" (published 1998), the culmination of two years of research and field work on the income and skills gaps among American workers. In January, 1999, "Winning the Skills Race" helped provide the framework for the White House Summit on 21st Century Skills for 21st Century Jobs.

Kaslow has reported and written extensively on unemployment caused by downsizing, trade, and technological change.

As a member of the Aspen Institute Young Leaders Program, she and a group of public policy makers, academics, and economists spent two years probing the problems of joblessness in the world's richest countries and developing prescriptions for change.

Under the auspices of the Washington-based Center for Strategic and International Studies, she co-authored a study on international labor issues for the 1994 Group of Seven Jobs Summit in Detroit.

She has published features and opinion pieces in the Wall Street Journal, The Washington Post, The Journal of Commerce, The International Economy, The Middle East (London), Institutional Investor (New York), World Monitor Magazine, International Development Review, CEO Magazine, Durrel's Money and Banking (Virginia), The Washington Quarterly, and other publications. She has been a regular contributor and editorial board member on Europe Magazine and Middle East Insight.

Her radio broadcast work includes commentary and reporting for Australian Broadcasting, Austrian Broadcasting, the BBC, Canadian Broadcasting Corporation, The European Report (Radio Features Corporation), Monitoradio, National Public Radio, Public Radio International, Radio America, and The Voice of America.

Her television appearances include The NewsHour with Jim Lehrer, CNBC, C-Span (separate programs on Iraq, the former Soviet Union, the US economy, the Clinton administration, Mexico and NAFTA, etc.), and a variety of cable and foreign broadcast shows.

AMY KASLOW

She addresses economic, labor, and media issues before an assortment of groups, including high school, university, and graduate students, think tanks, business organizations, and government agencies.

She has spent concentrated periods of time reporting from the Middle East (with special emphasis on the West Bank and Iraq), North Africa, Russia, the Balkans, Central, Eastern, and Western Europe, and Polynesia.

From 1989 to 1996, Kaslow was the lead economic correspondent for the Christian Science Monitor, covering the wide array of issues related to money. Her stories ranged from the cost of crime in the United States to the price of the former Soviet Union's disastrous environmental policies. She also reviewed the visual arts, theater, and music for the paper.

Before joining the Monitor, Kaslow was managing editor of International Media Partners (IMP), the New York-based firm publishing daily newspapers at meetings of the International Monetary Fund and the World Bank, the African Development Bank, the Asian Development Bank, and the Inter-American Development Bank. With IMP, she also edited a quarterly magazine on international development economics.

Ms. Kaslow wrote and edited for Institutional Investor and MidEast Report. She co-authored a sociological history guide to Israel and the occupied territories (Houghton Mifflin) contributing chapters on the West Bank and Gaza Strip.

This year, Ms. Kaslow will participate in the Brookings Institution US-Italy leaders program, and examine trade, finance, and security issues with American policy analysts, political leaders, and journalists, along with their European counterparts.

She is currently co-authoring a book on the plight of refugees before the Iron Curtain was raised in Eastern Europe and the former Soviet Union. It is both a reflection on the past several decades when international intervention peaked, and a look ahead to the future.

Kaslow is listed in the latest edition of Marquis' Who's Who in American Journalism, and Who's Who Among American Women.

A native of Washington, D.C., Ms. Kaslow attended the Holton-Arms School. She earned an undergraduate degree from Vassar College, where she studied politics and religion. She has pursued graduate work in Middle Eastern affairs both abroad and at the NYU-Princeton University Program for Near Eastern Studies.

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September 8, 1999

The Honorable F. James Sensenbrenner Jr.
Chairman, Committee on Science
U.S. House of Representatives
Suite 2320 Rayburn House Office Building
Washington, DC 20515

RE: Financial Disclosure

Dear Chairman Sensenbrenner:

Amy Kaslow appeared before your Committee on March 17, 1999 to provide testimony on "Why and How You Should Learn Math and Science" in her role as Senior Fellow with the Council on Competitiveness.

The purpose of this letter is to state that the Council on Competitiveness has not received federal funding in the past three years relevant to the testimony Ms. Kaslow presented.

Best regards,

John Yochelson
President

TO: THE COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

FROM: AMY KASLOW
SENIOR FELLOW
COUNCIL ON COMPETITIVENESS

RESPONSES TO FOLLOW-UP QUESTIONS FROM MARCH 17, 1999 HEARING
"Why and How You Should Learn Math and Science"

Responses to the questions from Republican members

Question One:

I am not sure whether anyone can quantify the exact amount of time it will take for the United States to have an adequate supply of sufficiently trained employees, because US industry is in a constant state of flux and the pool of would-be and incumbent workers is fluid. While it may be easy to determine future needs from what we know now, even unpredictable but near-term industrial innovations and international competition could greatly alter the demands and the timetable.

What is certain and obvious is that if we embrace the skills challenge immediately, we can expect fewer and perhaps less dramatic shortfalls in the future. We've seen a number of ways to boost workforce preparedness. Indeed, these measures will consume time and resources.

We've distilled the following eight principles from our two-year study:

1) No single business, group of workers, educator, or government agency can tackle the training challenge alone;

2) All parties must buy into training for it to be effective; each player must have an up-front stake in designing and instituting continuous learning;

3) Effective training requires that all parties do their part; employers must provide learning opportunities, workers must devote the time and energy to learning, and schools must teach marketable skills;

4) Education and training are not ends unto themselves; rather they are essential means for creating worker employability, upward mobility, and skills portability;

5) Learning helps accomplish worksite goals when it is convenient and available in smaller, more targeted increments;

6) Advances in technology-based learning are making education and training more accessible;

7) Performance measurement makes training more valuable by increasing accountability and transparency;

8) Training for the short-term is not sufficient; workforce preparedness requires thinking ahead, anticipating change, and taking action now.

Please refer to the accompanying report, "Winning the Skills Race," for a fuller explanation and anecdotal development of these important principles.

Question Two:

Quite simply, basic skills in math and science go a long way toward the readiness of workers to absorb new skills. It all boils down to their ability to learn how to learn.

For specific anecdotal evidence on the entertainment and hospitality industry (evidence that can be generalized to the entertainment industry at-large and beyond that to the American workforce at-large), please see our attached report, "Winning the Skills Race." You'll find a rich discussion on Orlando (Disney University, Valencia Community College sections), where a cluster of entertainment industries (and their suppliers) are competing for a very limited number of workers.

An invaluable resource on local, state, and national dimensions of this issue is Susan Kelley, vice president, Resource Development and Governmental Relations, Valencia Community College, 190 South Orange Avenue, Orlando, Florida. Telephone: (407) 299-5000 ext. 3410.

Because there is a tremendous amount of churning among entertainment and hospitality workers, there is a strong reliance on new entrants to the labor market. Michael Poole, an Orlando investment bankers who's chairman of Florida's Work and Gain Economic Self-Sufficiency program (a non-profit that administers the state's welfare-to-work program) may provide some insights into how best to build the skill base among the currently unemployable. Equipped with basic literacy math skills, for example, these ranks of unemployed could move into entry-level positions in the entertainment and hospitality industries, and broaden their skill base on and off the job.

Question Three:

Basic analytical skills are those most lacking in recent graduates -- and that includes GED recipients to students who have managed to make it through four-year institutions. The real issue here is that math, science, and literacy skills are sorely lacking. Without that very important base, it's very difficult for a worker to learn WHY and HOW he/she is performing a certain task, and practically impossible to develop a more efficient way to accomplish it.

The most shocking discovery is the one I mentioned during my testimony. The vast majority of new hires (and a significant portion of incumbent workers), regardless of industry, region, or education level, requires some level of remedial learning. Given the shortage of skilled workers, business increasingly bears the burden to give workers the basic tools to do a job.

Training requirements have far-outpaced the capacity of firms to respond. There is plenty of data to show that training pays off, but the training expenditures per worker fall far short of what is needed. Companies tend to do job-specific training geared toward the bottom-line of company operations. So while companies routinely invest in computer training, for example, a very small percentage actually offer formal training in basic reading, writing, arithmetic, and English language skills. This, despite surveys that show fifty percent of employers say their workers are deficient in those basic skills.

Companies in the United States are spending more on training than ever before (although the numbers of companies/higher amount of training per employee are biased toward the leading-edge firms), but there is a big disconnect between what the company with resources (typically the large corporation, but also the capital-rich technology firm) can spend and what the small or mid-sized firm can muster toward training and continuing education. There is a disturbing paradox: technology is generating a huge demand for skilled workers, but companies spend ten times more on beefing up their technological capabilities than they do their human resources.

For a broader discussion of this issue, see "Winning the Skills Race," pp. 30-47. A copy of the report is attached.

One of the most eloquent speakers on this subject is Charles A. Roberts, vice president of Total Quality Management, Ames Rubber Corporation, 23-47 Ames Boulevard, Hamburg, New Jersey, 07419. Telephone: (201) 827-9101. His information is fresh and his analysis is sharp.

Also, the American Society for Training & Development just released an excellent study "The 1999 ASTD State of Industry Report".

Responses to questions from Democratic members

Question One:

In many parts of the country, community colleges are the centers of learning proving most responsive to private sector needs. There's a good reason for this: they have their own bottom-line to worry about, and must ensure their own relevance by providing a reliable pipeline of workers.

These schools are literally capitalizing on skills shortages (and ultimately helping to redress them) by designing courses, work-study, and field experience to meet the ever-changing demands of industry. And perhaps more than any other type of academic institution, community colleges know the value in shortening the learning cycle and transforming students into workers with skills as soon as possible.

Increasingly, community colleges, once known as junior colleges or two-year institutions, are issuing degrees within one year, even six months, of successful completion of course work. Students are encouraged, if not expected, to return for continuous education, but the pressures of their own income requirements coupled with industry needs means that more and more students are entering the workforce faster, and with a purpose. They are armed with enough skills to land jobs that will soon command their return to the classroom (conventional or not) for even more know-how.

Exemplary institutions:

Valencia Community College in Orlando is a trail-blazer as a performance-based institution because it tracks its success rate in placing graduates into jobs (and looks at graduates' staying power in the workforce, years after they graduate). The better the placement numbers, the more qualified Valencia and other Florida state schools are for government funding.

Penn College of Technology has turned a potential problem into a lucrative business. Despite its remote, rural location in Williamsport, Pennsylvania, Penn College has secured partnerships with some of the world's major companies. The school is a major draw to Pennsylvania residents who are anxious to join the workforce with a marketable skill as quickly as possible. The courses, from culinary arts to automation, are grounded in basics (math, science, literacy reinforced) and highly practical. Firms are so convinced of the school's ability to train workers, they are willing to donate technical support, software, and other training materials (from cars to planes) for general learning.

Technical Vocational Institute (TVI) in Albuquerque, already New Mexico's largest community college, is staying in business by generating tailor-made programs for high-growth industries. These firms are hard-pressed to find workers in a state where welfare-dependency, high school drop out rates, and illiteracy rates are way above the national average. The fast-expanding health-care services, including New Mexico's hospitals and HMOs, are constantly searching for a wide variety of technically-skilled workers. TVI is providing niche workers, such as respiratory workers, but it is also targeting a virtually untapped market for retraining: the unskilled and minimum wage workers stuck in dead-end jobs.

TVI's priority is accessibility: the administration holds costs down, keeps enrollment open, holds classes at all hours, and provides counselors on hand to provide support. Given the growth in the aging population and the rapidly increasing demand for healthcare, TVI's success is a good bet. Like Penn College, TVI has engendered confidence among industry, and many firms have supplied costly equipment for training tools, such as state-of-the-art computerized systems that simulate respiratory failure. The clinical simulations help students to refine their critical thinking and decisionmaking skills.

Question Two:

Our entire report, "Winning the Skills Race" is a documentation of innovative, collaborative efforts among employers, workers, educators, and government to boost the skills of American workers. In it, we define the stakes, the players, and successes in the field. We identify coalitions, and define how and why they work.

Throughout the 86 pages of anecdotes and analysis, you will find many examples of government programs, initiatives, and involvement, and accompanying assessments of their effectiveness. See pages 40, 41, 42, 43, 51, 52, 53, 59, 64, 67, 69, 77, 82, 83 for specific municipal, state, inter-state, and federal government participation. We highlight some of the best government players in public-private sector coalitions.

A copy of "Winning the Skills Race" is attached.

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RESPONSES TO QUESTIONS THREE, FOUR, FIVE, AND SIX WILL ARRIVE SHORTLY BY E-MAIL FROM MARSHALL BERMAN, EXECUTIVE DIRECTOR, NATIONAL INNOVATION INITIATIVE, COUNCIL ON COMPETITIVENESS.

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Questions from Democratic Members of the House Science Committee
Submitted by
Dr. Marshall Berman
Executive Director
Council on Competitiveness
1401 H Street, NW
Washington, DC 20005

and member of the
New Mexico State Board of Education

May 11, 1999

Thank you for the opportunity to provide testimony on your hearings on "Why and How You Should Learn Math and Science." I have a Ph.D. in Physics and 34 years of experience at Sandia National Laboratories and in the aerospace industry. I appreciate the depth and quality of your questions, and apologize that I have had only one day to prepare my response. I would be pleased to provide additional information in the future.

What kinds of federal education programs could make a significant contribution to assisting state and local school systems with the implementation of science and math standards?

High quality standards are the key first step in meaningful education reform. Once developed, these standards must be disseminated to the teachers and accepted by them; the teachers then need to be adequately trained on the content, if standards-based education is to succeed. Instructional materials need to be aligned with those standards, as well as the assessments. Almost all states have chosen to develop their own standards, rather than adopt national standards in science and math. State standards range in quality from very good to very poor. These state-to-state variations can lead to inefficiencies, and misalignment with textbooks and tests. National science and math standards were developed by teachers, scientists, and mathematicians, and are not federal standards.

An appropriate role for the federal government would be to strongly encourage states to adopt these national standards, or at least to insure alignment between state and national standards to reflect the international character of the subject matter and to allow meaningful achievement comparisons on nationally-normed tests. Testing organizations should be encouraged to develop test items linked to those national standards. States that choose to deviate from nationally accepted standards might jeopardize the measured performance of their students compared to other states.

Another potentially valuable federal effort would involve funding research to address the following areas: provide information for benchmarking standards, assessments, instructional materials, and accountability systems; based on outcomes – i.e., student achievement – provide information on which states have developed the best professional development programs tied to standards. This funding could be provided to respected national organizations of math and science professionals, professors, and teachers who would perform the studies and publish the results.

Relative to impact on implementation of standards, are there particularly good or bad examples of federal programs? Are the federal programs effectively coordinated?

The Technology Literacy Challenge Fund has been successful. Statewide professional development grants from the U.S. Dept. of Education for integrating technology into the learning process for achieving standards have proven valuable. In New Mexico, the project is called Regional Educational Technology Assistance (RETA).

The NSF-sponsored Collaboratives for Excellence in Teacher Preparation appear to be making progress so far.

There appear to be many programs funded by DoEd, NSF, DOE, NASA, etc. that address science and math education. Improved coordination among federal math and science programs is essential. The NSF and DoEd in particular should keep each other fully informed on programs and their results in order to better focus federal dollars. However, it may be very difficult to develop inter-agency coordination and cooperation because of competition and "turf" issues. Congress should consider authorizing and funding an independent organization (preferably non-government, but it could be a neutral organization like the GAO) that would: 1) list all programs in any agency that are aimed at science and math education, including goals and funding; 2) ensure that those programs contain metrics to evaluate outcomes (and not just inputs); 3) report their results and recommendations to the individual agencies; and 4) provide Congress with its independent evaluation of which programs are effective and which are not.

A difficult aspect of implementing the math and science education standards is translating them into the materials needed for classroom instruction.
What is the availability of textbooks and other educational materials that conform to the math and science standards?

To my knowledge, little attention has been focused on this extremely important area. A study by a federal agency would be highly desirable. The National Science Teachers Association has developed a web-based system called sciLINKS that will coordinate Internet science material directly to chapters and pages in specific textbooks. A similar effort might be attempted in math, if it has not already been done. The federal government should provide direct support to these efforts so that science professionals, science teachers, and textbook publishers can align their work directly with the standards. These efforts should not be coercive. Rather, their obvious success should provide sufficient encouragement for their use in the states.

Is there any mechanism through which educational materials, which are claimed to conform to the standards, are formally reviewed and tested for the benefit of school administrators and teachers, so that they can select the best available materials for use in the classroom?

Not to my knowledge. Such a mechanism would provide an extremely valuable contribution to math and science education. The federal government should provide funding to national math and science teaching organizations such as NSTA and NCTM to create qualified boards to review educational materials, and publish their recommendations. Another approach would involve teachers sharing information on the quality and utility of various textbooks and web materials. This information could be collected, synthesized and published on the web hub page discussed below in question 6.

A recent RAND report on educational technology commissioned by the Office of Science and Technology policy recommends greater federal investment in pre-competitive multimedia education software R&D to help overcome market disincentives faced by software vendors that has resulted in a deficiency in content-based educational software. How would you characterize the quality and availability of educational software and other technology-based educational materials?

The quality of educational software, especially web-based, has improved dramatically over the last few years. However, access can be very difficult and time consuming. An extremely valuable contribution from the federal government would be to create a hub web page that links to all the important web-based science and math materials. The content would be organized by grade and by subject material, with a fast search engine. Teachers could then use this site in the classroom with ease. As an example, a 7th grade biology teacher could retrieve material to help her design her curriculum and lesson plans. In addition, she could select specific material on, for example, the evolution of mammals, or heredity, or photosynthesis. All other math and science topics would be addressed. The site would require permanent qualified staff to keep it updated. It might also include an "ask a scientist" link for personal support. The DoEd's Eisenhower National Clearinghouse site could provide a good start for such a comprehensive web site.

Many federal agencies (DoEd, NSF, DOE, NASA, etc.) and state and private organizations have created web sites devoted to various topics in math and science. However, a teacher, student, parent, administrator, or state or local policy maker, would have a difficult time finding the information required in a reasonable time. Coordinating all these sites with a single hub would be extremely beneficial to these stakeholders; in addition, such a hub site would highlight possible redundancies among the federal agencies and increase efficiency and coordination.

Is there a need for a systematic process for assessment of educational materials and a central clearinghouse for the distribution of the most effective materials?

Yes. The International Society for Technology in Education (ISTE) has supported since 1989 a process for assessment of software educational materials. There are also several non-profit and for-profit companies that evaluate education software. A federal role would be to provide a central clearinghouse to make this information available (on the website described above) with perhaps an independent assessment from NSF and DoEd.

Is more effort needed on dissemination of information about best teaching practices?

Yes. Information gathered in the TIMSS study on different international teaching practices is now being made available. The federal government should fund the necessary research and evaluation, and publish and advertise this information. Award-winning math and science teachers should be videotaped in their classrooms. These tapes should be made available to any

TESTIMONY OF
SHIRLEY M. MALCOM, PH.D
DIRECTOR, EDUCATION & HUMAN RESOURCES PROGRAMS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS)
BEFORE THE HOUSE COMMITTEE ON SCIENCE
MARCH 17, 1999

Mr. Chairman & Members:

Thank you very much for the opportunity to participate in these hearings focused on issues in science education raised by the Ehlers Report. The report, which represents the culmination of a wide ranging nationwide discussion, rightly points out our national interest in scientific and technical education in view of its importance to our workforce, our economy and the needs of our citizens. It is important to take stock and ask ourselves what is the extent of our needs in these areas and how well are we going about meeting these needs.

Last year the Congress approved legislation, later signed into law, that raised the ceiling for the number of H1-B visas to permit entry of additional highly skilled workers needed especially by the computer and information technology industries. *(Chronicle of Higher Education* 10/23/98, p. A32*)* Companies have been finding it extremely difficult to identify, recruit and place the number of employees that they need, who possess the requisite mix of skills, and are available for the job growth being experienced in those industries. In addition to the short term solution of raising the ceiling on immigration a strategy was put in place to collect fees to be used to support the education of more U.S. citizens to address the longer term issue of growing a human resources base sufficient for our country's future workforce needs.

In the interim student enrollments and degrees in computer science and engineering have been in steady decline. The jobs for college and graduate trained computer scientists and engineers have increased faster than our rate of production of these workers despite the strong demand being seen in computer and IT fields for some while. Scientists, mathematicians, and engineers are a small but vital component of our workforce and our failures to respond to the need to grow this segment must be viewed with alarm. Here are good jobs with high salaries and excellent career potential. Are students unable to respond to the demand because of inadequate earlier academic preparation; unaware of the jobs because of inadequate career counseling; dissuaded because of uninspired teaching, inadequate instructional infrastructure or weak connection between these jobs and their academic preparation? It is essential that we determine where the barriers exist to producing adequate supplies of the personnel that we need if we are to sustain the economic growth and competitive edge that the United States enjoys in computing, telecommunications, biotechnology and other such fields.

As other nations follow our lead into knowledge based industries their own citizens will be less likely to come to the U.S. for graduate education and less likely to remain to fill our workforce needs. Importing highly talented people is not an optimal long term strategy to address U.S. human resources needs.

As our business, service, regulatory, transportation and other systems have become more technically based and scientifically connected the need for advanced scientific, quantitative and technical skills has diffused out into many other areas of the workforce. As rightly pointed out in the Ehlers report we need technicians as well as scientists, engineers and mathematicians to support SME functions in the workplace. But our lawyers, judges, pilots, air traffic controllers, legislators and business people increasingly need the knowledge, concepts and ideas of science, mathematics, engineering and technology as well. So too do the service men and women who must defend our country as they use and maintain tanks, planes, ships, trucks and weapons, or detect the presence of biological and chemical toxins. Those who monitor the safety of our water supply and our food, who track infectious diseases, who keep us healthy, who fill our prescriptions, who care for us in hospitals and nursing homes all need a much higher level of SMET knowledge, concepts and ideas.

There are few professions that have been left untouched by the scientific and technological revolution in which we find ourselves. Yet we send too many into this revolution unarmed, lacking the knowledge, skills and understanding they need to do the Nation's work, to earn a living now and for the long term.

Earned Bachelor's Degrees, U.S. Citizens and Permanent Residents

	1989	1996
Engineering (all)	**66,947**	**63,066**
Male	52,160	47,623
Female	9,715	10,681
Underrepresented Minorities	4,805	6,974
Computer Science (all)	**30,963**	**24,405**
Male	19,901	16,093
Female	8,927	6,132
Underrepresented Minorities	3,742	3,784

The Needs of Citizenship

We regularly allude to the idea of science, mathematics, engineering and technology for citizenship. But I believe that it is essential that we ground this notion in some concrete examples so that we all understand the stakes. How does the public respond to issues of nuclear power vs. coal generated power or genetically modified plants or animals? How do we have discussions about personal or family health choices without fundamental understanding of human biology? How do we handle threats (real or imagined) to our children from an Internet that they can navigate where we as parents cannot? How can we exercise our responsibilities as voters or members of a jury? What happens when DNA evidence is presented and our jurors have no clue about how to interpret competing arguments of scientific experts? These concerns strike at the heart of our family responsibilities and our democracy. I fear that we are being led to a legal system that depends on people being uninterested, uneducated or confused by science based evidence, a frightening threat to our system of laws.

America Responds

The issues raised here are not new ones and the solutions that have been presented in the past are still relevant today. We must educate all students to much higher levels in science, mathematics and technology. We must tackle the challenge, no matter how difficult of re-education of the adult population who long ago left K-12 education. We must develop broadly based nationwide scientific and technical capacity for the long term. This means that resident in every state we must have public health, agricultural, transportation , statistical and other science and technology capabilities to ensure that the distributed nature of our data collection, reporting, controls and regulation do not jeopardize the interstate nature of our interactions, as people, food, water, air and services flow across state boundaries.

We must address the basic educational needs of all our people — the needs of those who will become SMEs as well as of those who will encounter SMET in other work. Common to all these ends is our compulsory education system. But we do not have a common system; we have 15,000 systems, locally controlled and autonomous. These systems must perforce act on behalf of our national needs for an S&T prepared workforce and technically prepared defense system.

Those of us in the science community have recognized the need to provide guidance and tools to these independently operating systems so that the core ideas that are commonly needed will be locally adapted and delivered. AAAS developed *Science for all Americans* in 1989 as a statement of these learning goals in science, mathematics and technology and *Benchmarks for Science Literacy* in 1993 to guide the teaching of core ideas across the grade span. The National Council of Teachers of Mathematics developed mathematics standards in 1989, and have recently revised these as *Principles and Standards for School Mathematics*, a Discussion Draft. The National Academy of Sciences published the *National Science Education Standards* in 1996. We now also have emerging technology standards developed by International Society for Technology in Education. We as scientific, mathematics and technical societies have no power or authority over school jurisdictions. We have hoped to influence states and localities by the quality and thoughtfulness of our work, openness of our processes and wide range of sectoral involvement. We can only urge districts towards rigorous standards that can support our national need for a next millennium workforce and citizenry. AAAS has developed other tools to assist districts as they assess the quality of their textbooks or of their efforts to promote learning for all student groups regardless of race/ethnicity, socioeconomic status, sex or disability.

In March 1999 the National Science Board (NSB) issued a very important report *Preparing Our Children: Math and Science Education in the National Interest.* The report recognizes that "it is both possible and imperative to develop national strategies that serve the national interest while respecting local responsibility for K-12 teaching and learning." The NSB offers four recommendations that promote student achievement in mathematics and science urging that "stakeholders must develop a much - needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in classroom teaching and learning."

I was a member of the task force that generated this report in the wake of the release of the TIMSS reports until the end of my tenure on the NSB in summer 1998.

While I no longer serve on the National Science Board I want to add my support to the recommendations they made urging a nationwide conversation and effort at developing consensus around standards and core learnings in science, mathematics and technology. The report points out that one in three students will move and thus change schools during their elementary and secondary years and that mobility alone argues for our making room for some common understandings within our traditions of local control.

I support local control of schools, and I also support national standards. I believe that the 15,000 roads that lead to the production of our Nation's human resources must to be guided by a road map that at least helps us understand the destination. Our standards must guide the way toward local derived and globally competitive curricula. I would add a quote from a recent NSB hearing by Board Vice Chair Dr. Diana Natalicio: "One of the things that I try to talk to people in school districts about.....is that while we are all respectful of their desire for local control, they seem to forget that they are not preparing their graduates to work or live locally. We are talking about a global competitiveness, and it seems very hard to square those two."

Higher Education

Increasingly post - secondary education is an essential element needed for our workforce. It will increasingly be 2 and 4 year colleges & universities that will deliver the last formal science and math courses that most people ever take. The view of science and mathematics, the concepts and ideas people take away with them, will be conveyed by the faculty of our higher education institutions. It is essential that we remember this, especially as it relates to the preparation of our K-12 teaching workforce. That 21st century teaching workforce will be the vanguard who will shape the national workforce of 2020. I hope that our foresight is 20/20 in recognizing that they must be provided the best that we can offer -- the knowledge, skills and ideas delivered using appropriate technology and other equipment. For it is they who ultimately keep America the world's great economic power.

The Congress has recognized the need to support the development of this teaching workforce as well as to help current teachers in a process of education and renewal. We must retain the integrity of programs established to ensure our national capacity in SMT education; when our health, our defense, and our quality of life are at stake we must insist on accountability for the use of resources that support education in the new basics of science, mathematics and technology.

Teachers for the 21st Century

Most of us who have gone on to pursue study in science, mathematics or engineering fondly remember those teachers who inspired, challenged and encouraged us. They expected much from us and gave much to us.

Most of my teachers in high school were actually prepared in the subjects that they taught us and, in those post Sputnik years, they had opportunities for summer study to extend and support their learning. Despite lack of equipment and facilities they approached science and mathematics teaching with eagerness.

One cannot help but contrast this with the current situation where teachers at the elementary level have had few post secondary opportunities to study and learn the science and mathematics they are expected to teach, possess minimal access to technology or the training needed to incorporate it as a teaching tool; where high school teachers of science & mathematics may likely be teaching out of the field of their major or minor with inadequate professional development opportunities, instructional equipment and laboratory facilities. The technology that will be integral to students' work & lives may not yet be an embedded part of their learning environment.

Teachers shape the future as they prepare our children. And who will shape the teachers for the new roles they must face?

Have we considered the role that teachers must face in preparing the students in SMT for the various roles and jobs they will assume in life? They must manage to understand and incorporate an expanding content base. In addition we ask them to respond to the psychosocial and other needs of their students, manage classrooms with too many pupils and too few resources while teaching too many hours a day with no time for preparation, planning or learning, little respect and low salaries.

The kind of SMT savvy teachers that we want for our children can earn twice or more their salary in another sector. Our local approaches to developing new teachers for the 21st century has meant that we all face shortages, potentially resort to emergency credentialling of underprepared persons and to raiding the neighboring district.

We need a massive mobilization to ensure the production and movement of highly qualified SMT teachers into our schools from a nationally available pool.

Just as Ms. Goddard, Mr. Smoot and Mr. Burton gave me my mathematics and science base so too must we provide for our children and grandchildren the teachers who can guide, motivate and inspire learning.

The Education of Citizens

The overwhelming majority of the U.S. population are beyond the direct instructional reach of our schools and colleges. Yet they need SMT information as well. While their jobs might provide or require specific training, reawakening their sense of wonder, excitement and inquiry, making them open to learning about science, mathematics and technology means that we must employ strategies that attract them to SMT, helping citizens see the science and mathematics that may have become commonplace. Museums, science centers, Internet, television and radio have taken on some of this work as have libraries.

But these media are still not reaching broadly across all populations. We at AAAS determined that we must be unabashedly opportunistic in sharing science with the public. We have sought to find topics that compel attention, such as health, and to use these in multiple formats to impart science context as well as immediate information about the health topic— be it the science of addiction or the ethical, legal and social issues related to the Human Genome Project. We have been willing to deliver this message where ever people are or where they come together. So we have had efforts based in all sorts of places such as in libraries, churches and senior citizens facilities. We at AAAS review trade books, video material and software as a way to guide teachers and librarians to the best among those available. *Science Books & Films* (now

SB&F and SB&F Online) has been the source for identifying quality books and materials for over 33 years, born as a post - Sputnik strategy to improve science learning by directing us to excellent science resources.

Another AAAS project has helped to stimulate the production of science communicators, assisting students of science, mathematics, engineering and medicine to gain journalism experience through placement in summer internships at print and broadcast media outlets. Roughly half of the more than 300 Mass Media Science & Engineering Fellows produced in the 25 year history of the program have taken these skills into their work as scientists often while assuming increased roles interacting with media. The other half have shifted careers to become full time communicators, including such luminaries as Dr. Michael Guillen of ABC, Richard Stone, and Joe Palca of National Public Radio.

They reach the public through the media, bringing science stories into our homes and offices — even informing our commute.

We find ourselves with a system of problems that, if taken together, threaten to overwhelm our ability to keep pace with the knowledge and skills needed to manage and maintain the technologically based society and economy we have created. Our need to import talent has been necessitated by our failures to develop talent, by expanding the talent base for technical and scientific fields. We have systematically underdeveloped women, minorities and persons with disabilities as crucial human resources for computing, engineering, telecommunications and biotechnology fields among many.

We need only to consider the extent of disruption predicted if we fail to address our Y 2 K problem to realize how embedded our technology and science have become —power grids, ATMs, missile warning systems, 911 systems. Like fish we do not see the water.

Nor do we see that the science and technology in our lives that we so take for granted force us to pay more serious and systematic attention to traditional notions that we have enshrined that may no longer serve us well. Our communities have expanded beyond our neighborhoods; our collaborators as well as our competitors may reside on the other side of the globe. Our reach may extend even beyond our planet.

Addressing the needs for global stewardship and sustainable human development, meeting our personal health needs as well as those of our families, being informed citizens and wise jurors, all compel us to a heretofore unseen need for scientific and technological savvy.

Shirley M. Malcom is head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science. She holds a Ph.D in ecology from The Pennsylvania State University and has served as a college faculty member as well as a high school science teacher. Dr. Malcom serves on a number of committees and boards that address issues in science and/or education policy. From 1994 to 1998 she served as a member of the National Science Board, (NSB), the policymaking body of the National Science Foundation; she was twice elected as a member of the (NSB) Executive Committee and in 1997 was appointed as chair of the Board Committee on Education and Human Resources. She also serves on the board of the Carnegie Corporation of New York and on the President's Committee of Advisors on Science and Technology (PCAST). Dr. Malcom is Co - PI of an NSF grant (with Dr. Maxine Singer, President of the Carnegie Institution of Washington) to develop a plan for the systemic reform of SMT education in the D.C. Public Schools.

She is a fellow of the American Academy of Arts and Sciences and the AAAS, holds seven honorary doctorates and has been recognized by Penn State and the University of Washington as distinguished alumna.

AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

Directorate for Education and Human Resources Programs

Shirley M. Malcom, Ph.D.

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March 16, 1999

The Honorable F. James Sensenebrenner, Chairman
Committee on Science
U.S. House of Representatives
Washington, D.C.

Dear Chairman Sensensbrenner:

This letter is sent as a statement of financial disclosure associated with my upcoming appearance as a witness before the House Science Committee on 17 March 1999. I am Co-Principal Investigator of a planning grant from the National Science Foundation to undertake SMT education reform in the DC Public Schools. My time devoted to the project is an in - kind contribution.

Sincerely,

Shirley M. Malcom

Shirley M. Malcom, Head
Directorate for Education
and Human Resources Programs

150 years of advancing science
1848-1998

Malcom Responses

Is our goal for our kids to be first in the world in math and science sufficient to assure us a scientifically literate society in the future?

1. The goal for our kids to be "first in the world in mathematics and science achievement" does not necessarily equate to assuring us a scientifically literate society in the future. "First in the world" is based on a testing paradigm that places a value on assessment performance that may reflect imperfectly an emerging consensus of what it means to be literate and numerate. Despite the issue of the imprecise tracking of assessments and our goals for students' understanding, our placement at the bottom of the achievement scale ought to be cause for real concern - indicating that students likely know little and understand less.

Of greater concern is a strategy that relies largely on the accumulation of knowledge and understanding by our youth in order to yield a literate society. Even as we work to make today's children scientifically literate it will require decades before they can influence and shape the ideas, policies and choices that affect the larger society through their participation as voters, opinion leaders and decisionmakers.

We must develop strategies that assist parents, grandparents and other family members as well as children in gaining greater knowledge and understanding of science and mathematics concepts and ideas.

You mention in your testimony that basic science and math knowledge is important for countless decisions made by adults in our society. If we want to offer strenuous math and science courses for those who are pursuing related careers, would it be

wise to offer "science for non-scientists" courses or should all K-12 students be exposed to the same stringent math and science curricula?

2. At what point do the preparation of the scientist or engineer and the preparation of the literate non-scientist diverge in terms of topic, depth and rigor?

In 1985 AAAS launched Project 2061 as an effort to clearly articulate the big ideas of science, mathematics, engineering and technology (SMET) that all students needed and the skills, knowledge and habits of mind that collectively comprise what we have called science literacy. These are the core understandings that we want for all students, those intended toward science, engineering and related fields and those not aiming for such careers.

Opting out of course work in K-12 science and mathematics prematurely reduces the opportunity to change one's mind about career intentions as opportunities present themselves and as new workforce areas emerge. Students with strong early interest in science and sufficient mathematics preparation often choose more rigorous coursework, often courses bearing college level credit, such as through Advanced Placement. But not all programs and schools make available more rigorous courses, having insufficient resources, low levels of demand or teachers unequipped to deliver these programs. This is often the situation in urban and rural areas. In order to adequately respond to the question we must separate several ideas that are often entangled: how standards relate to courses; and the relationship between content and performance standards.

In most programs, curriculum, courses and standards do not track precisely. It is possible for students to be in the same course and take different things away from the instruction. It is possible for students to be in very rigorous courses but to emerge without the core of knowledge necessary for literacy in science. It might be desirable and possible to provide courses with different approaches; all should be aligned with the standards; none should provide rigor at the expense of understanding or a level of engagement that precludes permit a later career choice for science or engineering. At 15 or 16 years of age it is not always clear who will or will not end up pursuing science or engineering careers. Education in SMET should be designed to keep options open rather than to close them.

What role for the media do you see that would have the greatest impact in education individuals throughout their lives? What voids, or gaps, do you see in the media's handling of science now that should be addressed?

3. "The media" includes a wide range of options — television, radio, movies, newspapers, magazines and Internet. It is not clear that these media perceive their role as one of educating but instead one of informing by reporting the news that affects people's lives. Adults having a basic education in science have access to new ideas and new knowledge conveyed by various media as science becomes news. Where media reports of science are included as a component of formal education young people can be guided to media as a lifelong source of information. The greatest difficulty in using media in that way is the disconnected manner of reporting, that is, where the larger context of the science is not provided. Adults need to be able to connect the ideas of the news to the science as they learned it and to see how that science is thus transformed.

Another difficulty emerges when stories appear about concepts where there is overwhelming consensus among the scientists who work in the area but the need for balance in reporting gives visibility to ideas in the margins, or where the news does not reflect good science. Many of these issues are resolved when there are science savvy reporters and editors and a commitment to science by the particular media outlet. And the restrictions of one form of media (e.g., the brevity of television) are being resolved by the presence of collateral associated media which do not share these restrictions (e.g., the expansiveness of the Internet). Issues related to the reporting on science also extend to reporting on science and mathematics education where thoughtfulness and care are also needed.

In addition to the media, how can we best relay to adults the information and knowledge that will help them make thoughtful decision?

4. In addition to media we must find other venues for adults to engage with ideas of science, especially as it affects their decisionmaking. I will outline a few opportunities below:

   (a) Engage adults as parents, guardians and caregivers through support of school associated or school mediated programs.

   (b) Connect adults with science through other venues, such as libraries, museums and other places of science, as well as in faith communities. AAAS has developed examples of programming that has used all of these venues and more, including literacy classes, education programs in correctional facilities and senior citizens groups.

(c) Explore online options, including formal coursework online.

(d) Provide scientifically accurate materials and training in their use to persons who engage with adults involved in such decisionmaking, including genetics counselors, mental health counselors and other health and medical professionals.

(e) Provide policymakers including members of Congress, with access to quality science that affects decisionmaking so that they include those findings as they interact with their constituents in discussing the issues.

I believe that we must expand our partnerships to such groups as trade unions, civic clubs, service organizations and other groups.

We must also include formal education in colleges, universities and extension programs as well as direct outreach by scientists and students of science doing interesting research.

What kinds of federal education programs could make a significant contribution to assisting state and local school systems with the implementation of science and math standards?

1. The systemic programs developed and supported by the National Science Foundation are promising to be very effective in catalyzing state and local level reform in implementing science and math standards. While the evaluation findings at the state level (State Systemic Initatives) have been mixed several statewide programs have provided strong positive examples of what is possible when catalytic federal efforts are joined with effective state based management and leadership. I would commend to the members' attention the programs in Texas and Puerto Rico under the leadership of Dr. Uri Treisman and Dr. Manual Gomez, respectively. These efforts suggest that federal seed funding can make a real difference in helping states shape and guide their internal resource decisionmaking vis a vis mathematics and science reform, forcing a rationalization and coherence of effort. Likewise the stimulus provided by seed funding of urban districts (Urban Systemic Initiative) and rural district clusters (Rural Systemic Initiative) has provided an organizing tool for implementation of science and math standards. Evidence of positive impace on teaching and learning is emerging from cities as diverse as El Paso, Chicago, Detroit and Memphis.

Other efforts that might prove beneficial include (1) support of tools for self - assessment for parents and community members to calibrate through review of sample curricula, test items and sample student work where their own system stands; (2) funding for technology and library resources to support standards-based science and mathematics instruction as well as support for renovation of science labs or for developing and equipping "lab mobiles" where renovation is not a reasonable option (especially where professional education of teachers is a prerequisite for accessing funding for capital improvement); (3) support for research to enable us to identify especially successful instructional strategies to assist all students to meet high standards in science and mathematics and for dissemination of the findings from that research.

In addition it is imperative that the federal funding already going into state and local districts support high levels of achievement with a focus on "remediation through enrichment" as a core strategy and that these include science as well as reading and mathematics as core competencies.

Relative to impact on implementation of standards, are these particularly good, or bad, examples of federal programs? Are the federal programs effectively coordinated?

2. Most really negative program impacts that were embedded in policy were removed with the re-authorization of ESEA. The removal of low level standardized testing requirements, especially using those not tied to standards, reduction of the strict remedial focus, inclusion of whole school and extended day programming have made it possible for much experimentation within Title I — possible but still not likely. Without clear examples, solid documentation, technical assistance in managing, and strategies for sharing a variety of successful and promising practices it will be difficult to

get programming in schools that goes outside of the traditions established by the programs.

A number of very worthy programs are either in place or in planning, for example the NSF's science teaching fellows and ED's 21st _Century Community Learning Centers, Community Technology and Parent Assistance programs. But these efforts must be made coherent and comprehensive with standards supporting goals; this can only be done in a community based effort to make the options provided by federal programs make sense for that community. This community based planning and development needs a system of accountability to the original federal program goals and mission to have legitimacy and to be effective. Systemic initiatives have been powerful organizing and planning tools to guide the use of resources with feedback into programming. I have generally favored a competitive granting process over block funding because of the planning and organizing it requires, the feedback it provides, the ongoing evaluation and program modification it engenders and the upfront local commitments it stimulates. The most successful efforts have emerged when block grant monies have become the venture capital for systemic programs. The least successful efforts come from chasing federal dollars that then go into separate offices and disconnected efforts, all with separate bureaucracies, some of which may be working at cross purposes.

Effective coordination must be achieved at two levels:

- that the federal programs do not require mutually inconsistent goals (that is, that they support a common vision); and

- that state and local systems provide a vision of mutually reinforcing program implementation with adherence to the original goals for which the resources were expended.

In all cases there is the need to move toward measurable results with evaluation and research as embedded aspects of program implementation from classroom practice to the statewide policy level. We must do more of what works and stop doing those things that don't work — and we have to be able to distinguish these two.

A difficult aspect of implementing the math and science education standards is translating them into the materials needed for classroom instruction.

- **What is the availabilty of textbooks and other educational materials that conform to the math and science standards?**
- **Is there any mechanism through which educational materials, which are claimed to conform to the standards, are formally reviewed and tested for the benefit of school administrators and teachers, so that they can select the best available materials for use in the classroom?**

3. In January 1999 AAAS Project 2061 released the results of a study of middle school mathematics textbooks. Of the 12 textbooks subjected to rigorous analysis for their alignment to standards only four recently published series received high ratings while the other more well-established titles were rated unsatisfactory. Results of a study of middle school science books will be make available this summer. (*Middle Grades Mathematics*

Textbooks: A Benchmarks - Based Evaluation) is available online at http://project2061.aaas.org/matheval/index.htm.

Preliminary review of science books at this level reveals that there is a paucity of quality materials.

The procedures for review were developed by AAAS Project 2061. The evaluation of mathematics textbooks was conducted by independent analysis teams of classroom teachers and college and university faculty with extensive knowledge of math content and of research on teaching and learning. The results of this collective effort, representing over 20,000 separate decisions related to content alignment and use of effective instructional strategies, has been made available to educators and administrators.

Project 2061 is making available the information as well as the training necessary for districts to undertake their own review of materials on their own timetable.

The major issue is whether this analysis will be used to guide purchasing decisions and whether the teacher professional development needed to utilize effectively the books that are aligned to standards is provided within these districts.

A recent RAND report on educational technology commissioned by the Office of Science and Technology Policy recommends greater federal investment in pre-competitive multimedia educational software R&D to help overcome market disincentives faced by software vendors that has resulted in a deficiency in content -

With the ability to develop such resources, listings, reviews and Internet links to facilitate purchase a virtual clearinghouse is quickly being brought online within AAAS. Funding is clearly the limiting factor for how rapidly this work can be done.

Is more effort needed on dissemination of information about the best teaching practice?

6. Not only is more effort needed on dissemination of information currently available about best teaching practices but also more research is needed to determine how to effectively incorporate findings from cognitive science, use of technology. The most fruitful immediate strategy is to include these in ongoing preservice and service professional development training for principals, lead teachers and supervisors charged with evaluating teacher performance and/or assisting in improvement of practice. In addition CD-ROM and other such resources could greatly enhance teachers' access to effective strategies. While some elements of practice are generalizable across fields others are specific to areas of content. Certain strategies are important to ensure that all students have access to the ideas such as accommodation for students with diverse learning needs (e.g., physical and learning disabilities) in regular classroom programs in science and mathematics.

based educational software. How would you characterize the quality and availability of educational software and other technology-based educational materials?

4. While difficult to assess the quality of the overall range of educational software and other technology-based educational materials there has been a real increase in the quality of educational materials over the past several years.

Singled out for special note is often the materials development supported by the National Science Foundation. This likely means that there is a math/science bias across quality materials since fewer competitive, peer reviewed federal grants programs have been available for materials development in other disciplines.

Is there a need for a systematic process for assessment of educational materials and a central clearinghouse for the distribution of the most effective materials?

5. There clearly is a need for the systematic assessment of educational materials, including textbooks, to determine how well these align to standards in science and mathematics and how likely the recommended instruction will lead to students' achieving the standards. AAAS Project 2061 has development a rigorous review process for textbooks and has released its findings for middle school mathematics. The Project makes this training available to district and other personnel, makes specific critiques available to publishers and so on. Other instructional materials, including videos and trade books in science, mathematics and social studies are reviewed by the AAAS review journal *Science Books and Films* (also available as SB&F Online).

ECUTEL
Ensuring Communications Evolve

John E. Harrison's Testimony to the House Science Committee.
Topic: ***Why and How You Should Learn Math and Science.***
Date: ***March 17, 1999 from 10am to 12pm***
Location: ***Room 2318 Rayburn House Office Building***

Mr. Chairman, and members of the committee, I'm John Harrison, co-founder of Ecutel and I'd like thank you for giving me the opportunity to testify. The issue of Math and Science education in the US is one I, indirectly, face everyday as the CEO. Ecutel is a small technology firm that is constantly recruiting scientists to make our products and to create new ones. We also need a large and technically savvy workforce to buy our products. Innovative and useful technology is the fuel of previous and our current economic growth. If this boom is to continue and companies like Ecutel are to succeed math and science needs to be in every grade of every elementary school and advanced math and science needs to be in all high school grades.

US colleges are some of the worlds most technologically innovative. In fact many foreign nationals attend US graduate schools to further their education. However, few US students have built the fundamental knowledge in elementary and high school to take advantage of these institutions. Ironically, these education levels pave the way for a knowledgeable workforce and stimulate the minds of future scientists to make innovative products.

I believe if I tell you a little bit about Ecutel you'll see how and why all US information technology firms equally suffer from a deficit of qualified electrical and computer science engineers that are US citizens.

Ecutel was formed 3 years ago by Dzung Tran and myself. We had a great idea to create a software product that supports the many requirements of the increasingly mobile and data hungry workforce. The Viatores-Mobile VPN is that product, and it is a networking tool that is based on components of the "Next Generation" Internet. Ecutel took these concepts and made them work in today's information systems. This is no small task, it required many hours of design before Dzung and I felt we could leave our previous jobs to form Ecutel.

In order to make Viatores we needed sophisticated engineers that could make it a software product rather than hardware. This is so people wouldn't have to carry alot of extra equipment when they roam the Internet, which is similar in concept to cell phone roaming. Furthermore we needed engineers to incorporate an encryption/decryption method so the data is not compromised as it flowed through the Internet.

We received 630 resumes in our first few months, and of those we considered qualified, none were US Citizens.

This caused more problems than Dzung and I thought it would. 1) In 1998 we had Immigration legal fees of $80,000, alot of money for a start-up, 2) We could not bid on contracts that required security clearances because there weren't enough engineers with US citizenship to qualify for a clearance. Dzung and I came from Military Intelligence, this hurt. 3) We couldn't work in some areas of encryption/ decryption (a necessity for secure communications) and 4) If foreign travel were required our engineers can only leave the US once, unless they receive a multi-entry Visa, which is both costly and timely.

If 20 years ago we had force-fed math and science education into the minds of US kids, Ecutel would be able to use the $80,000 to hire another engineer and to market the Viatores Mobile VPN more aggressively. Increased marketing would have given us more revenue, subsequently giving us funds to develop more innovative products, which ironically require more engineers. Furthermore, we would have a much more technically savvy workforce that could adapt more quickly to these innovations. It's a never-ending cycle in the world of information technology.

In 1998 the US was forced to increase its quota of H-1 visas from 65k to I believe 105k. The reason is clear, US innovation is outpacing its ability to innovate from within.

In the case of Ecutel, we have successfully circumvented some of the problems caused by the lack of American Engineers by working with other companies to minimize the amount of development required.

This is not a sound solution. We don't want to minimize development because that reduces the potential for innovation.

It doesn't matter if the company is as large as Microsoft or Ecutel with 15 employees. They both suffer from the same problem. Microsoft was once the size of Ecutel. It is companies like Ecutel that fuel this economy through their innovations. Large companies know this that is why they are constantly buying smaller firms so they can stay ahead of the curve.

I don't want to mislead you; I wouldn't trade any of Ecutel's engineers. In fact I deeply respect their tenacity and intelligence. I believe they contribute more than just technical know-how, they offer a cultural view on areas of the world in which Ecutel will eventually expand if it is to succeed in this global Economy. But, if we can't figure out a way to make it easier for small technology firms to maintain a qualified engineering staff at a reasonable cost then innovation suffers and so does our economy.

What Dzung and I have experienced as partners of a small firm in the high-tech industry leads us to conclude that 2 things need to happen in the very near future:

1. Math and Science education needs to be in a child's everyday activity so it increases their intellect and becomes 2nd nature to them. Even if they don't want to be scientists, we still need a technically savvy workforce to make use of these innovations. And
2. Until these kids are ramped up on technology, make immigration laws easier so we have the necessary technical skills in the hands of US companies to stay on top of the world's innovation curve.

This concludes my testimony, again thank you Mr. Chairman for this opportunity.

COMPANY MANAGEMENT BIOGRAPHIES

CEO, John E. Harrison

John E. Harrison is co-founder and Chief Executive Officer of ECUTEL. He has more than 8 years experience in managing the research and development of information technologies for the US Department of Defense (DoD)/Office of the Secretary of Defense/Command, Control, Communications and Intelligence (OSD/C3I) and ECUTEL.

After graduating from the University of Mississippi in 1990 Mr. Harrison worked for one year in the British Parliament as a Legislative Assistant (LA) to a Member of Parliament (MP). As a LA, he was involved in many of the legislative issues British telecom faced in the early nineties as well as the privatization of formerly state-run industries. Furthermore, he assisted in the drafting of the MP's position on the EURO, European telecommunication standards and third world debt restructuring.

Upon his return to the US, Mr. Harrison began work as Deputy Director of the Linked-Operations/Intelligence Centers Europe (LOCE), a US DoD Intelligence system developed to share information between NATO forces. After three years as Deputy Director he was promoted to the Program Manager position where he managed the systems substantial growth. During this period, the LOCE system was used by NATO/IFOR mobile ground forces as the sole means of Intelligence gathering at the height of the Bosnian Crisis.

After a successful term as the LOCE Program Manager, Mr. Harrison was again promoted to work directly in the Office of the Assistant Secretary of Defense/C3I/Special Technology. As Special Assistant in OASD/C3I, he oversaw budget issues and management problems of approximately 40 computer and communication systems within DoD. He worked with program managers from each of the systems to ensure budget and technical problems were solved through leveraging existing technologies within the Government as well as in the commercial sector.

Mr. Harrison formed Ecutel with Dzung Tran in 1996. The combined talent of the two has propelled Ecutel to the top of Internet communications for the mobile workforce. Mr. Harrison's vision for secure, real-time Internet communications can be experienced through Ecutel's flagship product called the Viatores Mobile VPN. Viatores is the first Internet communications tool that raises the mobile workforce (sometimes referred to as the "Road Warrior") from 2nd to 1st class network users. Military, law enforcement and Fortune 1000 companies use Viatores to increase the productivity and reduce the cost of supporting their mobile workforce.

CEO: Roles and Responsibilities

As CEO of ECUTEL, Mr. Harrison works to develop and maintain the company's vision to become a market force in mobile Internet communications. In order to make this vision a reality, his daily responsibilities include the oversight of marketing, product development, production, finance, and customer support associated with ECUTEL's products and services.

Further information

- March 17, 1999 Mr. Harrison testifies to the US Congress, Committee on Science on the Impact of Science Education on our Economy. Mr. Harrison represents Small Tech Firms in these hearings.
- February 5, 1999 Mr. Harrison presents the Viatores Mobile VPN at the Microsoft Tradeshow in Washington, DC.
- November 2, 1998 Mr. Harrison appears on the cover of Internet Week Magazine as they profiled Ecutel's Viatores Mobile VPN
- October 1998, Mr. Harrison appears in 5 publications as they preview the Viatores Mobile VPN.

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ECUTEL
Ensuring Communications Evolve

Honorable James Sensenbrenner
Chairman, Committee on Science
Suite 2320 Rayburn House Off. Bldg.
Washington, DC 20515-6301

Dear Chairman Sensenbrenner,

Thank you for inviting me to testify to the Science Committee on the Issue of *Why and How You Should Learn Math and Science* on March 17, 1999.

This letter is in response to your request for financial information pertaining to any revenue Ecutel received or receives from the Federal Government, which directly supports the subject matter of this testimony.

Ecutel does not receive any funding from the Federal Government that directly supports this subject matter.

If you need any further information please feel free to call me at 703-354-4140 and I would be happy to help.

Sincerely yours,

John E. Harrison

)0 Cherokee Ave., Suite 505 Alexandria, Virginia 22312 Tel: 703-354-4140

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APPENDIX III: Materials for the Record.

THE NEW REPUBLIC
A Weekly Journal of Opinion
March 29, 1999

Color Blind

By Tamar Jacoby

The African American absence in high tech.

The weather was unmistakably Californian, and the venue looked modern enough: a state-of-the-art convention center in Santa Clara, in the heart of Silicon Valley. But the demonstration last summer--60 noisy protesters carrying placards and chanting slogans--was straight out of the Deep South, circa 1960. "Intel is not `inside' low-income and minority communities," one picketer proclaimed as the protesters circled the sunny courtyard, vying for the attention of the computer scientists entering the trade fair in the hall. "Intel, Intel, you're no good," another chant went. "Bring computers in the 'hood!"

It was a small demonstration, but, for civil rights groups in California and beyond, it marked the opening of a new frontier: the battle to close the "digital divide" between an increasingly computer-literate mainstream and the people of color who, it is claimed, are once again being left out. The activists' long list of complaints begins with hiring practices. According to The San Francisco Chronicle, which ran a much-discussed series on the issue about a year ago, only four percent of those who work in Silicon Valley's trademark high-tech companies are black, and only seven percent are Hispanic--about half of what the figures would be if they were proportional to the local population. Though many California computer firms are government contractors, most do not meet federally mandated goals for minority hiring. In the past decade, more than a dozen have been cited for affirmative action violations, and several, including Apple, have paid hefty fines.

Spurred by the Chronicle series, community groups have organized to demand more minority hiring, more contracting out to minority-owned businesses, more diverse boards of directors, and corporate environments that show more "respect for cultural differences"--not just in Silicon Valley but in information-technology (I.T.) companies nationwide. Groups like the Rainbow/push Coalition and the Greenlining Institute (a major player in the fight against redlining in California) are pressuring Intel and Microsoft. They and others lobbied heavily in Congress last summer to block a bill, eventually passed, that significantly increased the number of foreign high-tech workers to be admitted to the country this year as immigrants. Black intellectuals are starting to show interest in the question; The Atlantic Monthly recently ran a ruminative piece, by poet Anthony Walton, about why blacks as a group are suspicious of technology. And, in December, Jesse Jackson joined the battle, using the occasion of a Federal Communications Commission hearing to denounce "segregation" in the high-tech sector.

The rhetoric is overheated and the tactics possibly counterproductive, but Jackson and his allies are onto something: blacks are woefully underrepresented not just in I.T. but, far more broadly and fatefully, in science--in the research, teaching, and commercial uses of every scientific discipline. Blacks account for roughly twelve percent of the U.S. workforce but only four percent of the doctors and five percent of the jobs in engineering, computer science, and scientific research. The gap arises early in life, with blacks scoring on average more than 200 points lower than whites on the math section of the SAT. A citywide test last year in Boston revealed an even starker contrast: while nearly 30 percent of eleventh-grade whites were "proficient" or "advanced" in grade-level math, only two percent of blacks were. In higher education, the picture looks even bleaker: blacks earn only five percent of the bachelor's degrees in science and engineering and only two percent of the doctorates in related fields. And the vast majority of blacks with any scientific inclination go into medicine rather than hard-science fields like physics or chemistry.

If the past 30 years have taught us anything, it is the folly of aiming for proportional representation by race and ethnicity. Few fields attract all types of people (or both genders) equally, and, even if they did, experience and aptitude often make some groups more successful than others in a given area at a given time. But the large and alarming gap that persists today between black and white achievement in all areas of science is far more than a temporary proportional skew--and, in the long run, it can only spell disaster for black America. By 2000, 60 percent of all U.S. jobs will require technical skills. There are currently close to 200,000 unfilled jobs in the computer industry alone--a field expected to generate more than a million new openings by 2006. No wonder the industry wants to import more foreign workers and even community colleges are scrambling to prepare graduates for entry-level work in the high-tech sector.

To be sure, this problem has been apparent for a long time, and there has been no shortage of attempts to deal with it. It was in the early '70s that corporate America first noticed the shortfall of black engineers: then, they accounted for only one percent of the total. The reason seemed obvious enough--blacks' historical exclusion not just from scientific careers but also from ordinary educational opportunities--and together government and industry resolved to remedy both problems as quickly as possible . No effort was spared in the ensuing campaign--nothing short of an all-out push by some of the most powerful institutions in the country. The National Science Foundation (NSF) and the National Institutes of Health (NIH) mobilized their massive grant-making machines. The nation's largest and most visible corporate donors vowed significant support, both in cash--for scholarships--and outreach efforts. Engineering schools and other universities began to develop specialized minority programs, and--all the way down the education chain--enterprising teachers experimented with ways to interest the youngest black children in math and science. Altogether, over the past 25 years, more than $20 million has been spent on scholarships by the three most concerned industry giants (Exxon, IBM, and G.E.) alone--and upward of $3 billion by the NSF and NIH.

Their efforts have not been fruitless: the number of black engineering graduates has just about tripled in this period. But the total is still disappointing. "Nowhere is the promise for minorities greater than in engineering," says an anguished George Campbell Jr., president and CEO of the nonprofit National Action Council for Minorities in Engineering (nacme). "We've made progress, but the gains are tenuous, and now, for a variety of reasons, black engineering enrollment is declining. We can't afford this. Think of the costs to society--a society divided into technological haves and have-nots."

In today's polarized race debate, one hears a wide array of explanations for this black-white gap. Liberals tend to talk about discrimination--in school, in college, and in the workplace. Conservatives, who use words like "discipline" and "achievement," believe that the problem is more internal (rooted in psychology and motivation) than external (the result of racism). Some people in the education establishment think the explanation may be as simple as lack of exposure to science in early grades. But an increasing number of experts on both sides of the ideological divide now talk about the role of culture. Most use the term without racial connotation to mean the culture of hard work and accomplishment. But a few--and not only Afrocentric activists who differentiate between white and black learning styles--think there may be something about "black culture" or black attitudes that is preventing black people from doing well at science.

Some of these cultural arguments seem more suggestive than others. Economist Thomas Sowell, for one, speculates that Africa's long history of geographical isolation hampered its cultural development. Still other cultural explanations hold that the problem is less aptitude than interest. Whether because of past exclusion or maybe the way technological innovation historically has been used against blacks (examples include iron shackles, compasses--necessary for transatlantic slave crossings--and the cotton gin), today's African Americans aren't drawn to science and don't want to excel at it. Nigerian anthropologist John Ogbu, now at the University of California at Berkeley, believes that blacks avoid success in science because, like schooling in general, it means "acting white." "People think of math and science as something that white males do," Ogbu says, "and for a black to succeed in these disciplines raises questions about his or her membership in their own group--about their racial solidarity and blac k identity. This can be conscious or unconscious, but it leads to avoidance of math courses and low effort."

Suggestive and wildly speculative alike, all of these theories are just that--still untested and unproven. Perhaps as a result, the search for "why" is being overshadowed by a competition among remedies. For civil rights activists and others who think the gap is caused by continuing racism, the solution is obvious: more effort on the part of mainstream society. The picketers at the Santa Clara trade fair made this case when they demanded that Intel "close the digital divide"--as if one company, even a com pany as big and powerful as Intel, could simply solve the problem overnight by hiring enough people or committing more resources.

Greenlining, Rainbow/push, and the black education establishment agree on a familiar list of what is wrong. I.T. companies don't do enough to hire and retain minority scientists; despite the efforts of the past 25 years, universities haven't figured out h ow to find or train black students; the rollback of affirmative action proves how little white America cares; most teachers don't expect enough of the blacks in their classrooms; and academia continues to rely on allegedly biased standardized tests.

If only it were that simple--and if only the solution were so readily at hand. In truth, if the extraordinary effort of the past 25 years has demonstrated anything, it is the limit of what politics and money--and affirmative action--can do to help black w ould-be scientists help themselves up the ladder of achievement. Outreach, scholarships, and retention programs have made a difference at many college campuses and corporate R&D departments. But a number of signs suggest that most of those who can be help ed in this way are already benefiting--and that it will take a whole new kind of effort to help any significant number of others. As it is, not many young blacks emerge from high school with the qualifications to make it in higher-level science. Not only are their SAT scores often lacking, but no more than six percent have taken the courses, like precalculus and physics, necessary to prepare them for a technical major. (Alarmingly enough, among nonminority kids, only 15 percent have taken these subjects.) And the few minorities who are prepared get a lot of help to go further.

This assistance comes in many shapes and forms. Organizations like nacme scour the United States for minority students they think could succeed in engineering school, then provide them with full scholarships, paid summer internships, and the possibility o f jobs with companies like Exxon and IBM. Other young blacks who show an early aptitude in math or science spend one or more summers in their high school years at one of the many intensive "bridge courses" sponsored by engineering schools and other univer sities. When they get to college, most of these lucky few are contacted by administrators of yet other enrichment and counseling programs who guide them through undergraduate school and, when possible, beyond. At all but a very few schools, these outreach and retention efforts go hand in hand with extensive admissions preferences. But, even with this help, only a third of the minority students who arrive at college intending to major in engineering end up earning that degree (compared with 60 percent of A sian and white kids).

The limits of what mainstream goodwill and affirmative action can do are even clearer in the corporate world. Poor science education and an ebbing of interest in engineering among all Americans have left the I.T. industry with a desperate shortage of empl oyees, and most young people who come out of college prepared for high-tech work are deluged with offers. Recruiters and college officials say this is even truer for blacks than for whites, as the story of

Kyra Massey, a young, black mechanical engineer recently profiled in Fortune, confirms. Well before she graduated with a bachelor's degree from Florida A&M University, Massey was offered a $42,000-a-year entry-level job at AlliedSignal, and within nine months she received two other, more lucrative offers, before accepting a $50,000 package from Hewlett-Packard. "If you find a black engineer or a female engineer, everybody wants her," says Cara Finn, vice president of employee services at Silicon Valley's Remedy Corporation. Big firms like Exxon, G.E., and IBM offer huge signing bonuses both for new minority recruits and for existing minority employees who help bring them in. Then, when the newcomers arrive at the company, the human resources department typically spends a small fortune trying to raise the odds that they'll stay, fighting notoriously high minority attrition rates with counseling, mentoring, and firm-sponsored minority networks.

It's true, as critics charge, that Silicon Valley firms rarely make the kind of heroic recruitment or retention efforts familiar at larger, older corporations. Many California companies are new and struggling, in a highly competitive business, and few can afford employees who cannot carry their weight. But it's also true that most of these enterprises, often founded in the last few decades by iconoclastic baby boomers, have no history of the kind of discrimination that is usually thought to justify affirmative action. More important still, the high-tech industry is one of the world's purest meritocracies. "If you're good, you get hired," says David Ellington, co-founder and CEO of the black Internet service NetNoir, "and on the whole that makes Silicon Valley less racist than the rest of society."

But even the hardest-nosed I.T. entrepreneurs recognize the need to include more blacks in the growing mass of computer-literate Americans, and many companies are searching for new ways to reach out, largely through education programs. Microsoft, which has given $24 million for minority education in the past five years, is now the largest contributor to the United Negro College Fund, with Sybase, a software developer, and Hewlett-Packard not far behind. Intel's efforts are no less impressive. The giant chip maker funds summer programs for minority high school and college students; it gives generously to both four-year and community colleges, neighborhood computer labs, and science presentations in public schools--all targeted whenever possible to women and people of color.

The big idea here is enlarging what's called the "pipeline"--preparing a larger number of people who will eventually be able to do the work in the I.T. industry. Instead of a thumb on the scale or a color-coded double standard, this approach involves a long-term commitment to education and development of minority talent. It will probably be more expensive than preferences and will surely take longer. But it holds out the promise of solving the problem rather than merely papering over it, as affirmative action mainly does.

Of course, some pipeline programs are better than others, and it's not clear that educators are zeroing in on what really works. A lot of the big Silicon Valley companies have focused on putting high-tech equipment in the hands of minority students. But education experts are increasingly skeptical that this is the answer--especially for the all too many minority kids in failing schools who are not learning how to read or do basic arithmetic. Many pipeline programs are driven by untested ideological premises, such as the idea that black students can learn only from black teachers or that their "learning style" is somehow fundamentally different from that of other kids. It doesn't help that most of the efforts are poorly evaluated, if at all.

Still, a few things are known. The programs that are most successful at producing black scientists are at historically black colleges and universities. Though they enroll only 25 percent of black college students, these schools grant 40 percent of black science and engineering degrees, and they account for six of the ten undergraduate schools that send the largest number of blacks on to earn science doctorates. Private and public, small and large, these colleges vary enormously--making it difficult to generalize. Yet, if Xavier University of Louisiana is any guide, the key is an emphasis on basics--both the basics of science and the basics of how to get through college.

A small school with a modest endowment and entering freshmen who are relatively poorly prepared, Xavier combines support services with rigorous academic standards. Introductory chemistry and biology courses set the tone. The faculty members have created their own textbooks, which walk students step by step through subjects, introducing basic vocabulary, emphasizing and reemphasizing key concepts, even dictating exactly how to work problems. "These kids need to learn some basic things before branching out, " pre-med adviser J.W. Carmichael explains. "I don't leave anything out. I take them through every single detail.... People say we're hand-holding. Yeah, we are, particularly in the early years."

Xavier's rules of conduct also stress the fundamentals--discipline is intense and unyielding--but it is in the area of mentoring and counseling that Xavier's effort is most evident, completing what some educators call the "socialization" of the students, many of whom are the first in their families to go to college. Counselors guide their charges through every aspect of campus life, from how to register for their first classes through applications for jobs and professional schools. Academic advisers meet weekly with underclassmen. Free tutoring is available and encouraged. At Florida A&M, or famu, also a historically black school, the socialization includes a dress code and instruction in how to introduce yourself to strangers, as well as extensive exposure to the manners and morals of corporate life. By the time they graduate, both Xavier and famu students have learned how to learn, and their discipline and work habits pay off handsomely--particularly in science. Famu is a favorite recruiting ground for corporations looking for both engineers and business majors, and, in 1998, for the sixth straight year, tiny Xavier sent more black students to medical school than any other college in America.

Integrated institutions have pipeline programs for black students, too--and they have done much to help people like Michele de Coteau, a Berkeley engineering graduate and Rhodes scholar. A working-class child from a poor section of San Francisco, de Coteau showed an early aptitude for math, and, when she got to high school, she was recruited to take part in special summer courses that brought kids to the Berkeley campus to do more advanced, intensive work. At another summer program at the renowned Rensselaer Polytechnic Institute, she got her first taste of research and learned to fill out a college application. Then, when she got to Berkeley, de Coteau was one of the first participants in a pioneering enrichment course created by mathematician Uri Treisman, now at the University of Texas at Austin and something of a guru in the pipeline movement.

Like most pipeline interventions, Berkeley's offers a wide array of services: financial aid, counseling, mentoring, summer study, research opportunities, and more. But its most touted feature is the series of workshops that Treisman developed in the late '70s to help the large number of minority students that he noticed washing out of freshman math and science courses--which are usually big, intimidating classes where professors encourage the brightest kids and leave the others to fall behind. Building on the insight that black students at Berkeley seemed unusually isolated--unlike Asian students, they didn't study in groups and seemed to keep their social lives separate from what they did in the classroom--Treisman put together a multiracial group of two dozen freshmen for an extra, intensive section of calculus, where he encouraged them to study together. Cannily, he made sure that nothing about the class suggested it was remedial; on the contrary, all of what he calls the "theater" surrounding the seminar told students that they were in for an extra challenge and that they were expected to excel. Twenty years later, Treisman's workshops are still the hottest idea in minority science education, and they have been imitated at more than 150 institutions.

The imitations vary widely, but all involve small groups, extensive mentoring, and a culture of high expectations; and most aim to give black students an extra boost just before or during the intimidating freshman courses that are the all-important "gateway" to further science study. It is a combination that seems to produce impressive results. Eighty percent of Treisman's students in Texas earn Bs or better in freshman calculus. (At Berkeley in the '70s, before he started his workshops, 60 percent of blacks came away from a similar course with

Ds and Fs--if they didn't simply drop out.) Stanford, MIT, and the University of Maryland's Baltimore County campus all have their own successful versions of the program, and one of the best, at Georgia Tech, has eliminated the performance gap between black and white engineering students.

Without more rigorous independent evaluation, it's hard to say exactly why these programs work. Some advocates think it's the watchful counseling, not unlike the hand-holding at Xavier, that seems to be especially important for kids whose parents haven't been to college and don't have middle-class attitudes toward education. Other minority educators stress the teachers' high expectations, something even good black students like de Coteau do not always experience in other classrooms. Most persuasive for an outside observer is the programs' culture of discipline and accomplishment. De Coteau and her fellow students learned that, if they worked hard, they could succeed. They experienced, perhaps for the first time, the way achievement can be its own reward and tasted the intoxicating self-confidence that comes only with effort and hard-won success. Yet, surprisingly, this is not what de Coteau emphasizes about her experience at Berkeley. Instead, like Treisman himself, she believes that what really mattered was the esprit de corps that developed among her black and Hispanic classmates, who learned from one another that it was possible for them to do well in science--even as well as the Asian and white kids they saw excelling in their gateway courses. "Without the close friends I made there," she says, "I never would have made it. We inspired each other. We felt we were all in it together. It wasn't us against the white kids. But it was important to affirm ourselves and not get intimidated."

The success of Treisman's programs and those at historically black colleges leads back, then, to the loaded question of race and culture: Is there something specifically racial about blacks' failure to do well in science--something that can best be remedied by a race-conscious solution? Many educators and successful black scientists insist not: the answer, they argue, is better teaching--for black students of all ages as well as for whites. But just as many professionals and minority students agree with de Coteau that blacks come to school with special disadvantages and need special help in overcoming them.

What are the disadvantages exactly? As different as different people's answers are, after a while, most seem to point in the same direction. "It starts with stereotypes, black people's stereotypes about math and science," says Silicon Valley veteran Michael Fields, a former president of Oracle USA and one of the most successful blacks in the business. "The biggest problem is not discrimination--not at all. It's people's preconceptions about `the math thing.'" Is the issue just that math and science are associated with white people, as anthropologist John Ogbu suggests, or is there something special about these disciplines that blacks find particularly frightening? Another African American who has made it to the top of the high-tech pyramid, Intel executive and chemistry Ph.D. Cheryl Shavers, thinks there is something different about these subjects. "Science is extremely challenging," she explains. "There is a right answer and a wrong answer. If you don't get the right answer, you feel like a loser.... [B]lack kids are especially sensitive to this because many of them already feel like losers."

Of course, segregated group study has its own potential costs, and it could encourage students to think in racial categories. But, as long as workshops like Treisman's go on producing results, the idea of minority group study will remain popular. The sprinkling of white students in most of these programs will probably protect them against charges of reverse discrimination, and, in the short-term, most will continue to be used as a complement to preferences--a way to retain poorly prepared kids who otherwise might not make it-- rather than an alternative, before students apply to college. Meanwhile, even observers like de Coteau who believe that the problem begins with black students' feelings of inadequacy don't seem to see how preferences fuel that self- doubt and undermine the culture of accomplishment that the best pipeline programs work so hard to instill.

The 25-year struggle to close the digital divide holds a rich lode of lessons about the black-white academic gap, not just in science but also more generally. By now, everyone acknowledges that ultimately the answer is to enlarge the pipeline. Yet the civil rights movement and others continue to distract from that task by demanding an impossible quick fix from academia and industry. Similarly, just about everyone understands that personal effort and a culture of accomplishment are critical. But too many activists and educators still encourage failing kids to blame "the system"--teachers, tests, and admissions policies--rather than reminding students that ultimately they are responsible and only they can do the hard work that will make the difference for them. What can be done about ambivalent black attitudes toward schooling? How do we help poor families make the leap to middle-class child-rearing practices? How do we uproot the racial fears that lead black students to avoid the challenge of science and other subjects? As long as we don't know the answers--and we are a long, long way from knowing them--we are only fiddling at the edges of the black-white science gap.

The newest and most encouraging trend in pipeline programs is to start them earlier, not just in high school but better yet in middle school and, if possible, earlier still. Alongside the push to provide minority students with access to computers, teachers are experimenting with more "hands on" instruction (fewer abstract concepts, more tactile demonstrations). Others stress the "news you can use" approach (looking to the technology of cars or even turntables to teach science). Still others, like the best college programs, use smaller classes and demanding teachers to create a community of learning and accomplishment.

Carlmont High School, in the heart of Silicon Valley, does a little of all of this as it struggles to educate the children of high-tech entrepreneurs along with those from poor and heavily minority East Palo Alto. Walking through the building--a once-stylish, cantilevered affair, now a little run-down and old-fashioned looking--one is immediately struck by the contrast between the kids on the fast track and those hanging out in the hallways. Not all of the former are white, and Principal Debbra Lindo is visibly proud of her staff's success in helping some of the poorest and least likely black students onto the path toward higher learning. Still, as one walks through the locker-lined halls, it's hard not to feel a little discouraged. There is so much yet to do, and it is so easy for even a talented child to fall through the cracks--if she isn't noticed by a teacher or recruited along the way for special intervention. Carlmont offers higher-level science courses, but only a small percentage of students take them; and it would be unrealistic, Lindo says, to require algebra or a year of science for graduation. This may not be the school's fault--not even the best teachers can work miracles--but, as long as it's true, for whatever reason, the digital divide will gape as dauntingly as ever.

Tamar Jacoby, a senior fellow of the Manhattan Institute, is the author of *Someone Else's House: America's Unfinished Struggle for Integration* (Free Press).

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PREPARING OUR CHILDREN:

MATH AND SCIENCE EDUCATION IN THE NATIONAL INTEREST

An NSB Report on Mathematics and Science Achievement

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PREPARING OUR CHILDREN: MATH AND SCIENCE EDUCATION IN THE NATIONAL INTEREST

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I Introduction: Student Achievement as a Shared Responsibility

Almost 10 years ago, President Bush and the state governors "set goals aimed at preparing all the Nation's children to improve their achievement in core subjects and outpace the world in at least math and science by 2000."[1] The urgency of the ensuing national debate on how to improve academic achievement by U.S. elementary, middle, and high school students – and the consequences of failing to do so — remains undiminished today. At issue is who ostensibly defines the content to be learned, and who ensures the opportunity to teach and learn it well. While resolutions will be local, the dialogue that precedes them should reflect experiences from across the Nation, as well as research and evaluation of processes and outcomes, including international comparisons.

The National Science Board (NSB), the governing body for the National Science Foundation, is charged with advising the President and the Congress on matters of national science policy.[*] Last July, the NSB issued *Failing Our Children*, a statement urging "all stakeholders in our vast grass-roots system of K-12 education to develop a nation-wide consensus for a common core of knowledge and competency in mathematics and science."[†] "In the new global context," the statement continues, "a scientifically literate population is vital to the democratic process, a healthy economy, and our quality of life."

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[*] As stipulated in the National Science Foundation Act of 1950, as amended. 42.U.S.C. Sec. 1861 *et seq.*

National Science Board. *Failing Our Children: Implications of the Third International Mathematics and Science Study*, July 31, 1998, NSB-98-154 (hereafter referred to as the "July statement").

Just as the inability to read puts a child at risk of truancy and becoming a school dropout, deficiencies in mathematics and science have become a barrier to higher education and the 21st century workplace. Preparation of new generations for entry to both of these worlds is a community responsibility; it cannot be delegated solely to teachers and schools. Thus, the articulation of K-12 content standards with college admissions criteria is vital for conveying the national expectation that educational excellence improves not just the health of science, but everyone's life chances through productive employment, active citizenship, and continuous learning.

Moreover, the future of the science enterprise is renewed through a continuous flow of talent into the Nation's science and engineering workforce – talent that embodies certain core skills and competencies derived from education and training shaped by the highest standards of quality.[*] The NSB believes that nothing is more essential to the health of the science enterprise than human resources – the *people* who are prepared for careers that produce the next generation of knowledge, products, and processes in all sectors of the economy.

It is imperative to raise the voice of the science and engineering communities,[†] as the chief practitioners of research and education, in the national dialogue on improving the teaching and learning of mathematics and science. Together with elected officials, school administrators, classroom teachers, parents, and employers (especially those from knowledge-based industries), scientists and engineers bring a valuable perspective on mathematics and science as a way of knowing, a transferable skill, and a citizenship tool as we enter a new millennium.

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[*] In its 1980 reauthorization in the Science and Engineering Equal Opportunities Act (42 U.S.C. 1885) and subsequently in Title I of the Education for Economic Security Act (20 U.S.C. 3911 to 3922), NSF was given additional authority to increase participation by groups historically underrepresented in science.

[†] The words "science" and "scientists" sometimes appear in this report as a shorthand for the principal participants in the community of scientists, mathematicians, engineers, technologists, as well as math and science educators at grades K-16. They are all central to what is sometimes called "SMET education."

In a culture dedicated to opportunity for all, nothing is more important than preparing our children for the future workplace. In the science, mathematics, engineering, and technology (SMET) education of all students, K-12 through post-graduate, the NSB believes that rigor and depth of content are keys to preparation.[*] Education reform is a long-term proposition. In this report, the Board sets forth what it considers the necessary conditions for academic achievement, including concurrence on what constitutes "basic skills" for the 21st century.

Science education in the U.S. has received several national wake-up calls since the launching of Sputnik in 1957, including the publication of *A Nation at Risk* in 1983. More recently, the Third International Mathematics and Science Study (TIMSS)[2] warned that America's children ages 13-17 are, on average, not leading, but *lagging* the world in mathematics and science achievement. Every parent – not just scientists, educators, and employers – should be alarmed by these results.

The school systems of high-performing countries share characteristics that can be gleaned from the TIMSS data. These data range from content analysis of textbooks, curricula, and classroom videotapes, to ethnographic case studies and surveys of teachers' attitudes and students' coursetaking.[3] The characteristics that emerge include:

- a coherent vision of what all students in each successive grade should learn, with a focus on a few topics in depth both in their textbooks and classroom instruction;
- instruction delivered by teachers well-prepared in the subject, who benefit from out-of-class opportunities to develop lessons, and consult regularly with teachers and other resource persons; and
- alignment between what is expected, taught, tested, and rewarded for students, teachers, and schools.

All high-performing countries show student gains between grades 3 and 4, and again between grades 7 and 8. The U.S. does not. Even in 4th grade, where U.S.

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[*] One of NSF's three overarching goals is to "Achieve excellence in U.S. science, mathematics, engineering, and technology education at all levels." This "requires attention to needs at every level of schooling and access to . . . educational opportunities for every member of society" *NSF in a Changing World: Executive Summary of The National Science Foundation's Strategic Plan* (1995, NSF 95-142): 3.

students do well relative to those in other countries, their performance in physical science areas is weak, foreshadowing their average performance at 8th grade and their unacceptably poor showing at 12th grade. When we compare our K-12 schools and curricula in light of the TIMSS results, we find many teachers lacking good content preparation and, in the aggregate, a muddled and superficial curriculum. Even excellent pedagogy cannot inspire learning what the world's best-performing children are expected to know in these circumstances. Amidst the diversity of students and systems – large and small, wealthy and disadvantaged, urban and suburban and rural – there is an overarching reality: in too many American schools there is too little quality science and mathematics being taught and learned.

In addition, while U.S. graduate education remains the envy of the world, the declining interest and participation of domestic students in science and engineering must be taken as a disturbing sign that K-12 mathematics and science education is failing to renew, expand, and prepare our talent pool.[4] This decline clearly suggests that the performance of U.S. students signals uneven preparation for college-level study, a lack of readiness for the world of work, an accumulating disadvantage in the global economic competition to come. A further implication, more subtle and harder to demonstrate, is that as American schools fail more youngsters, this nation's capability to innovate, solve problems, and produce – *to sustain world leadership* – is in jeopardy.

With such a prospect in mind, the National Science Board asks how to address the national interest through local strategies that promote academic achievement in mathematics and science. Drawing on research and analysis, this report asserts that stakeholders working in their home communities can converge on what matters most for mathematics and science achievement – rigorous content standards, high expectations for teaching and learning, teachers well-prepared in the subjects they are teaching, and meaningful measures of accountability. Such convergence can help clarify shared responsibility, identify where contention resides, and suggest how research can illuminate both what is known and what needs to be known. The Federal role in elevating education practice and student performance is catalytic and analytical – one resource among many helping to foster the conditions under which all students, schools, parents, and communities can together boost academic achievement.

II. Content Standards for All Schools

No topic in education has stirred more emotion than "standards." As communities debate the essence and intended influence of standards on what teachers teach and *their* children learn, the *national* interest often recedes from view. The national interest is grounded in the importance of a strong, competitive workforce for the future of the Nation and a citizenry equipped to function in a complex world. That interest encompasses what every student in a grade should know and be able to do in mathematics and science (among other core subjects). Today's mobile society means that local schools have become a *de facto* national resource for learning.

The NSB believes that stakeholders must develop a much-needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in classroom teaching and learning.

In the remainder of this section, we address two issues that underpin this core recommendation: the need for standards in a mobile population, and the role of nation-wide standards in the context of local school governance.

A. Student Mobility

In the July statement, the NSB notes that "Students often move several times during their K-12 education, encountering varying curricula and instructional materials that cover an increasing number of topics while sacrificing depth and rigor." National data show that 31 percent of the 8th grade class of 1988 changed schools two or more times between grades 1 and 8.[*] Ten percent changed schools two or more times during high school, i.e., between 1988 and 1992. White students were less likely to move than

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[*] U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988, Base Year (1988) and Second Follow-up (1992) Surveys. Data that extend this time series will not be available until 2000. Also, mobility rates in urban districts are probably higher than this national average. The Houston Independent School District, for instance, reports a 38 percent mobility rate in 1998 (C. Lanius, personal communication, Sept. 18, 1998).

ethnic minorities, students who lived with their mother and father during the 8th grade were less likely to have changed schools than students in single-parent or other family situations. And students in low-income families were more likely to change schools than students with family incomes exceeding $20,000. According to the U.S. Department of Education, "students change schools for academic, personal, and family-related reasons. Those who make frequent school changes can experience inappropriate placement in a new school, lack of continuity of lesson content, disruptions in social ties, and feelings of alienation. Teachers may also find it difficult to identify and meet the academic needs of the highly mobile student."[5] This "mobile student" segment of the school population also has implications for other phenomena that affect the Nation's workforce – high school dropouts and completions.[*]

Special local programs alone will not compensate for the learning deficiencies created by the movement of children between school districts. A sounder approach is student access to exemplary teachers and support that begins with agreement on the "minimum requirements" of what, say, all 5th graders should know and be able to do in mathematics and science. Without defining these requirements, mobility becomes another disadvantage that accumulates, leaving some children further behind or labeling them inappropriately.

If the content of instruction encountered by students in 5th grade math classes in Missoula is unlike its counterpart in Cincinnati, then every transfer student – regardless of what she has been taught and is prepared to learn – will have little opportunity (exacerbated by the lack of continuity) for making academic progress. This situation is all too common across the U.S.[†]

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[*] Most strikingly, Hispanics – the fastest growing segment of the school-age population – drop out of high school at higher rates and attain lower levels of education than other groups. U.S. Department of Education, National Center for Education Statistics, *The Condition of Education – 1998*, Indicator 24 <//nces.ed.gov/pubs98/condition98/c9824a01.html>.

[†] Content standards need not encroach on teachers' creativity in presenting material. As Finn et al. ("Four Reasons Why Most [State Standards] 'Don't Cut the Mustard.'" *Education Week*, Nov. 25, 1998: 56, 39) put it: "Standards, if done right, should not standardize what happens within schools. Rather, they should free the schools from top-down dictates while obliging them to focus on results. This will enable various school models to emerge, from 'progressive' to 'traditional,' and everything in between – a range of

A remedy is *content* – instructional materials, teaching, and testing aligned to something beyond, or in addition to, a local standard that gauges learning by every old and new kid on the block. The needs of the mobile student population beg for some coordination of content and resources. Structures and practices must help to prevent mobile students – who tend to be ethnic minorities, poor, or come from one-parent families – from slipping through the cracks of a school or district. Better record-keeping is only a start. To help recognize learning needs, classroom teachers must be better informed about the content preparation of newly-arrived students.[*]

Student mobility illustrates a systemic problem that demands systemic solutions. Unless the needs of the mobile student population are addressed, other bigger problems loom. If school imparts too few skills, the teenager is at greater risk of dropping out and becoming dependent on another set of social services. If transience and mobility between schools reduces students' access to quality teachers, instruction, and materials because of content that lacks consistency across districts and grades, then guidelines that transcend statewide practices and help to minimize the disruptions of change should be welcome.

B. *Standards and Accountability*

A decade ago, national standards in mathematics and science began to be designed by the American Association for the Advancement of Science (AAAS), the

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choices that can better serve the needs and learning styles of children and the passions and talents of teachers" (quote from 39).

[*] For example, the IEP (Individualized Education Program) is a locally administered but nationally standard tool used to guide and monitor services specifically designed to meet the needs of special education students. Depending on the disability, a statement of goals, setting, and supports necessary for the student to perform academically must be completed, with parents' consent, before services can be provided, as stipulated in the Individuals with Disabilities Education Act (IDEA). One idea is to encapsulate a version of the IEP in a "digital portfolio," e.g. a CD-ROM, containing each student's academic history – what courses s/he has taken and learned at what level of proficiency. This would travel with the student, so that "receiving" districts would not have to rely on the records and responsiveness of "sending" districts. A version of this innovation was a prize-winner in the 1998 Bayer/NSF Award for Community Innovation competition that challenged student teams to use science and technology in developing solutions to real-life community problems. A team from Atlanta proposed T.A.S.K.—Tracking and Saving Kids Force, creating a clearinghouse to assist parents in locating, retrieving, and storing the school and immunization information of homeless and transient students. See <//www.nsf.gov/od/lpa/events/bayernsf/winrelea.htm>

National Council of Teachers of Mathematics (NCTM), and the National Academy of Sciences (NAS), in close consultation with all stakeholders in education -- preschool to graduate school. These standards, while evolving, have been endorsed – generically if not specifically – by organizations as diverse as the American Federation of Teachers, The Business Roundtable, the Education Commission of the States, and the CEOs of over 200 Silicon Valley high-tech companies.[6]

The reality today is that virtually all states have curriculum frameworks that use the NCTM, AAAS, and the NAS documents as points of reference for teaching challenging mathematics and science.[7] These independently-generated frameworks signify an emerging consensus that offers a national resource on which local districts across the U.S. can draw as they define "basic skills" and formulate guides to classroom practice.

The existence of frameworks has not translated content standards into widespread classroom practice.[8] "Translation," of course, requires change – teacher by teacher, textbook by textbook, classroom by classroom. There is no "one size fits all" implementation plan. In this sense, the Federal role in the national movement toward standards is at best supportive. "National" standards do not mean "federal," "federally mandated," "standardized," or "homogeneous." Indeed, the relation of "nation-wide" standards to state frameworks and to what is actually taught in classrooms remains murky at best.[*] Imparting core competencies neither defines an entire curriculum nor precludes locally-held beliefs and prerogatives about the content of that curriculum.

Rather, math and science competencies must try to anticipate future national needs as convergence on the definition, content, and use of standards continues to grow.[9] For example, NSF, NASA, and other agencies have funded instructional materials development, yielding models that reflect professional consensus on what constitutes teachable content standards in mathematics and science.[*] The evaluation and distribution of such materials help districts, teachers, and administrators make informed choices among innovative resources.[†]

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[*] In the words of a recent commentary, "Standards should not prescribe teaching methods, devise classroom strategies, or substitute for lesson plans. Standards are about ends, not means. Yet many states either do not understand this distinction or do not agree with it. Too often, pedagogy and ideology have seeped into

In a recent review of the status of standards, the President of the National Center on Education and the Economy identified what will reinforce high academic performance.[10] Attaining such performance, by pursuing the following, is consistent with the states' role as chief accountability agent:

- assessments set to the standards (if you cannot accurately measure progress toward the standards, they are unlikely to influence behavior);
- curriculum set to the standards (what is taught is what is learned);
- incentives for the students to meet the standards (students presently have incentives to stay in high school to get the diploma, but little incentive to take tough courses or work hard);
- a relentless focus on results (develop a strong rewards-and-consequences system tied to the standards and directed to the staff of schools; making progress would be rewarded, repeatedly dismal performance would put jobs at risk);
- a modern accountability system (put performance standards in place, institute appropriate measures of progress, and decide how to raise the students to the standards); and
- accurate, detailed, up-to-date data on student performance (readily available to parents and policymakers).[‡]

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their standards." See C.E. Finn, Jr., et al., *op.cit.*, 1998.

[*] NSF programs, for instance, support a range of projects. In its NSF oversight role, the NSB would apply the national policy analysis of this report to NSF programs designed to address the myriad needs of school systems. In its 1999 Government Performance and Results Act performance report, NSF will evaluate the outcomes of its investments in Education and Training. With this NSF report is in hand, the NSB could better address NSF portfolio questions.

[†] For example, see AAAS' Project 2061 at <http://project2061.aaas.org>. This "Guidebook to Examine School Curricula" features a "curriculum analysis procedure" for evaluating existing classroom materials. It is part of the *TIMSS Resource Kit* found at <//timss.enc.org/TIMSS/timss/curicula>.

[‡] "What standards should do, among other things, is tell teachers what the experts think [based on research] is most worth teaching. . . Looked at that way, the changes that have taken place since the start of the standards movement are impressive, but not nearly enough. That is hardly cause for despair. It is cause for redoubled effort." M.S. Tucker, "The State of Standards: Powerful Tool or Symbolic Gesture?" *Expecting More* (Newsletter on Standards-Based Reform), 1 (Spring 1998): 2. Also see D. French, "The State's Role in Shaping a Progressive Vision of Public Education," *Phi Delta Kappan*, November 1998: 185-194.

The reality of educational accountability lags these attainable prerequisites for student achievement. As *Quality Counts '99*, a survey of state policies on accountability, concludes, "most have a long way to go in making their accountability systems clear, fair, and complete." The survey finds, for example, that 49 states (all but Iowa) have or are drafting standards in core subjects, 48 now test their students, and 36 publish annual report cards on individual schools. Fewer than half publicly rate the performance of all schools or identify low-performing ones. Only 16 states have the power to close, take over, or overhaul chronically failing schools. While 19 require students to pass tests to graduate from high school, only two have attempted to tie teacher evaluations to student performance. Finally, while most states rely on test scores to help determine "rewards and sanctions," the focus is primarily on schools rather than individual educators, penalties are threatened but not imposed, and there is no agreed-upon strategy for fixing failing schools.[11]

Accountability may begin with standards. But because content standards are mere abstractions until melded with instructional and student performance standards, teaching and assessment are intimately (and perhaps inevitably) bound up in discussions of standards.[12] Bound up as well are expectations – not just of students but also of teachers, parents, and the Nation. Test performance, too, must be interpreted relative to something, be it expectations or course offerings, and coursetaking (i.e., curriculum and the opportunity to learn it). Without a standard, tests become mere comparisons among students – norm-referenced tests – uncalibrated by content. They also risk missing or mismeasuring complex cognitive and performance proficiencies. In the very worst case, they measure what children *bring to* school, not what they *learn in* school. Student achievement, in short, should reflect the value *added* by schooling, not the distribution of class or home (dis)advantages that characterize the U.S. student population. Standards should help us think about the relation of science literacy to basic skills. What those skills are fuels the ability to apply knowledge to new contexts and problems. Controversy over *how* students acquire them seems to distract communities from achieving what most avow is in the national interest.

Teachers' cognitive expectations, or what they believe the child can learn, set the stage for performance. Additionally, the child must be convinced of his/her own capability. Asserting that "all children can learn" reflects the power of standards and accountability: increasing mathematics and science graduation requirements (to at least three and preferably four years of each); eliminating remedial courses (and the tracking and ability grouping they denote), and holding principals, guidance counselors, and teachers – along with students themselves – accountable for academic improvement. All students can be held to the same high standard of performance, so that race, ethnicity, gender, physical disability, and economic disadvantage can diminish as excuses for subpar performance.[*]

Likewise, parents' expectations influence achievement. The research literature indicates that parents decide to become involved in the education of their children due to three principal factors: what they believe is important, necessary, and permissible for them to do with and on behalf of their children; the extent to which they believe they can exert positive influence on their children's education; and their perceptions that the child and the school want them to be involved. Various factors, but particularly change of residence, inhibit parental involvement.[13]

Of course, adoption of curricula with challenging content and parental involvement will not willy-nilly boost American students' academic achievement. Curriculum innovations have historically failed to influence teaching and learning practices due, in part, to teachers' scarce opportunities to learn new content and improve their practice. Although teachers are instrumental in student learning, no *one* component can transform the quality of schooling, improve student achievement, and communicate to all stakeholders (especially parents) why changes should be tried, indeed supported, before positive results will be observed (much less measured). That is why a systemic vision – the U.S. as a "common market" for knowledge workers with transferable skills – is needed to integrate all components of teaching and learning.

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[*] Such changes are examples of "policy drivers" that are central to the program design of NSF's Urban Systemic Initiatives (USI). While each USI may follow a different reform trajectory for achieving the goal of system-wide, challenging mathematics instruction for all students, progress toward this goal – as reflected in student achievement data – is the chief outcome for which the districts are held accountable. "Such improvements are called 'systemic' because they fundamentally alter the school systems in which they occur." See L.S. Williams, *The Urban Systemic Initiatives (USI) Program of the National Science Foundation: Summary Update*, July 1998, quote from 3; and *The National Science Foundation's Urban Systemic Inititiatives (USI) Program: Models of Reform of K-12 Science and Mathematics Education* (Westat*McKenzie Consortium, October 1998).

For U.S. student achievement to rise, a consensus on standards, from classroom to statehouse, must be forged. The recommendations discussed below all contribute to effective implementation of the Board's core recommendation. Implementation is addressed to areas of action for which stakeholders share responsibility. Of special emphasis are NSB proposals for how the science community can collaborate to advance the consensus on core competencies, and how national and international experience should inform decisions about mathematics and science teaching and learning.

III. Building a Seamless Education System, K-16

Content standards that nurture a science-literate population serve the national interest. Implementing standards creates opportunities to change both the conditions for learning and the performance of U.S. students. This is a call to transcend a dangerously balkanized system and assist local communities to support teachers and learners of mathematics and science, K-16. To reiterate the NSB July statement, "No nation can afford to tolerate what prevails in American schooling: generally low expectations and low performance, with only pockets of excellence at a world-class level of achievement."

The NSB proposes three areas for consensual national action to improve mathematics and science teaching and learning: instructional materials, teacher preparation, and college admission. We address each in turn.

A. Instructional Materials

U.S. students, TIMSS showed us, are not taught what they need to know. Most U.S. high school students don't take advanced science; they opt out, with only one-quarter enrolling in physics, one-half in chemistry. Instructional materials are not the only culprit, but surely contribute to this science-aversion. As the president of the American Physical Society puts it, "Both common sense and modern educational theory tell us that students, when asked to memorize disconnected facts without truly understanding them, quickly lose interest in the subject."[*]

From the TIMSS analysis we also learned that mathematics and science curricula in U.S. high schools lack coherence, depth, and continuity; they cover too many topics in a superficial way. In short, TIMSS demonstrated that *content matters* – and students must have the opportunity to learn it. While most countries introduce algebra and geometry in the middle grades, only one in four U.S. students take algebra before high school. Topics on the general knowledge 12th grade mathematics assessment were covered by the 9th grade in the U.S., but by *7th* in most other countries. In the general science assessment, topics in the U.S. were covered by 11th grade, but by *9th* grade in other countries.

Students' exposure to challenging mathematics and science content is limited, it seems, by what is offered them and the coursetaking choices they make. According to TIMSS, 90 percent of U.S. high school students stop taking math before getting to calculus. Among college-bound students, half had not taken physics or trigonometry; three in four had not taken calculus, while one in three had taken less than four years of mathematics.

The TIMSS analysis also disclosed that most general science textbooks in the U.S. touch on many topics rather than probe any one in depth. The five most emphasized topics in 4th grade science texts accounted for 25 percent of total pages compared with an international average in the 70-75 percent range. General mathematics textbooks in the U.S. contain an average of 36 different topics; texts in Japan cover 8 topics, in Germany, 4-5. In middle school (grades 5-8), while the world proceeds to teach algebra and geometry, the U.S. continues to teach arithmetic. All high-performing countries show student gains between grades 3 and 4, and again between grades 7 and 8. The U.S. does not. Like others, the NSB believes this reflects a muddled, unfocused, repetitious, and superficial curriculum.

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[*] Content is closely monitored due to its potential impact on the kinds of instructional materials that textbook publishers produce for students' nation-wide. For example, see J. Basinger, "Coalition Lashes Out at California's Proposed Science-Education Standards for Schools." *The Chronicle of Higher Education*, Sept. 3, 1998 <//chronicle.com/daily/98/09/98090301n.htm>.

Without some degree of consensus on content for each grade level, textbooks will continue to be all-inclusive and superficial. If used as the foundation for instruction, these textbooks will fail to challenge and motivate students to exercise their curiosity and experience mathematics and science as ways of knowing.

At their best, curriculum materials energize learning. But we learn in different ways. Curriculum developers therefore offer alternative formats for their textbooks.[*] Some emphasize rote learning, others coherent knowledge of science content and process, sometimes with the concurrent use of mathematics.[14] Few introduce real-world interdisciplinary problems and serve as the foundation for Advanced Placement courses, school-to-work transition courses, or the challenges of a liberal arts college education.[†] Most innovative science curricula, for instance, seek coherence, integration, and movement from concrete ideas to abstract concepts. Furthermore, they stress inquiry, a connectivity among disciplines, a concern for societal implications, and a scientific "way of knowing." Taken together, they would foster in the high school graduate what we would term "science literacy."

Teaching and learning to high standards cannot be the province only of *some* schools, teachers, and students. To be systemic, 15,000 school districts should not engage in the same curriculum-based experiments and repeat all-too-familiar mistakes. They should reap the benefit of what other districts have tried. Since most decisions on textbooks and related instructional materials are made at state or local district levels, they frequently incorporate some mechanism for citizen review and advice.

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[*] Middle school math textbooks, for example, offer few excellent choices. Separate reviews by AAAS' Project 2061 and a parent group called "Mathematically Correct" found little agreement on which texts to recommend. They differ over learning strategies, with the Project 2061 review team of 24 teachers and mathematicians giving *Connected Mathematics* consistently high marks on the content criteria or "benchmarks" used to rate a dozen textbooks. See D.J. Hoff, "Reviews of Math Text Parallel Pedagogy Rifts, *Education Week*, Jan. 27, 1999 <www.edweek.org/ew/current/20math.h18>. Also see M.T. Battista, "The Mathematical Miseducation of America's Youth," *Phi Delta Kappan*, February 1999: 425-433.

M.G. Bardeen and L.M. Lederman, "Coherence in Science Education," *Science*, vol. 281, July 10, 1998, pp. 178-179. By reconceptualizing the traditional sequence of biology, chemistry, and physics, for instance, science curricula face serious barriers to implementation. Materials and tests would have to change. Teachers would require professional development to compensate for *their* lack of command of content. Teamwork among teachers with the requisite expertise would be essential. Nothing short of a restructured school day and calendar would need to be instituted – in all, systemic change.

Recommendation 1. *To implement its core recommendation (above) through instructional materials:*

i. ***The NSB urges (a) broad adoption of the principle of citizen review; (b) active participation on citizen advisory boards by educators and practicing mathematicians and scientists, as well as parents and employers from knowledge-based industries; and (c) use of public forums to foster dialogue between textbook publishers and advisory boards in the review process.***

ii. ***Accompanying this process should be an ongoing national dialogue on appropriate measures for evaluation of textbooks and instructional materials for use in the classroom. The NSB urges professional associations in the science community to take a lead in stimulating this dialogue and in formulating checklists or content inventories that could be valuable to their members, and all stakeholders, in the evaluation process.***

B. Teacher Preparation

Public opinion overwhelming favors "ensuring a well-qualified teacher in every classroom" as the top education priority. Indeed, teachers – once viewed as central to the problem of student underachievement – are now being recognized as the solution.* In teacher preparation there is a "multiplier effect" that can span generations. While a sound undergraduate science education is essential for producing the next generation of scientists, it is equally critical for future teachers of science. The refrain, "you can't teach what you don't know,"[15] surely applies.

There are many signs that teachers in the classroom cannot rely on their undergraduate education when teaching mathematics or science. According to the

National Commission on Teaching and America's Future, as many as one in four teachers is teaching "out of field." The National Association of State Directors of Teacher Education and Certification reports that only 28 states require prospective teachers to pass examinations in the subject areas they plan to teach, and only 13 states test them on their teaching skills.[16] Many students who turned away from mathematics and science in college become elementary school teachers.

The NSB thus believes that improving future teacher preparation is crucial for improving their performance in the classroom and the achievement of their students. One commentator has noted that all the experimentation in full bloom across the U.S. – "class size, physical resources, local administration – can help. But good teaching is the vein of gold. To mine it, we'll have to pay more to attract and keep the best. And we'll need to be sure we get our money's worth by requiring strong preparation, and performance up to measurable standards."[17] There is a threshold of preparation and competence that all future teachers of mathematics and science must initially reach, and then augment, as their careers unfold.

The distributed character of our education system and the diversity of higher education institutions illuminate the problem. Over 1250 colleges and universities prepare future teachers, and 700 are regularly audited by the National Council for the Accreditation of Teacher Education (NCATE), which has contractual relations with 36 States. But NCATE accredits programs, while the 50 States credential teachers,[18] and the teachers are employed by 15,000 independent school districts. This recipe for distributed responsibility has resulted in much variance in course requirements for budding teachers and uneven quality in teacher education. Maintaining, enhancing, and "scaling up" or spreading quality in a distributed system are difficult at best. Codified, widely shared goals and standards in teacher preparation, licensure, and professional development provide mechanisms to overcome these difficulties.

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[*] Teaching was recently hailed as "the essential profession." See J. Archer, "Public Prefers Competent Teachers to Other Reforms, Survey Finds," *Education Week*, Nov. 25, 1998: 6. The survey results for *The Essential Profession* can be seen at <www.rnt.org/tep.html>.

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What we have learned about mathematics and science teachers already in the classroom is dismaying. While most teachers embrace a vision of high standards for all students, cooperative learning (in small groups), and the use of technology (computers and calculators), their instructional strategies fall short of the vision.[*] Many teachers lack support to plan and deliver quality instruction. 1 in 2 teachers feel inadequately prepared to integrate computers into instruction, and 2 in 5 feel inadequately prepared to use math or science textbooks as a resource rather than as the primary instructional tool, or to use performance-based assessments. Fewer than 1 in 3 teachers feel prepared to teach life science, and only 1 in 10 feel prepared for the physical science course they are teaching. In addition, more than a third of elementary teachers, and more than half of high school mathematics and science teachers in 1993, felt unprepared to involve parents in the education of their children!

Thus, in addition to teacher preparation, we have the continuing challenge of professional development, where school districts update the knowledge, skills, and strategies that teachers bring into the classroom. No professional is equipped to practice for all time, i.e., be an inexhaustible "vein of gold." We cannot expect world-class student learning of mathematics and science if U.S. teachers lack the confidence, enthusiasm, and knowledge to deliver world-class instruction.

As a body of scientists and engineers, the NSB believes that content background matters for classroom performance. For example, the proportion of Presidential awardee teachers in mathematics and science with degrees in the fields they teach is much higher than in the total teacher population.[†]

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[*] The most recent national study, based on a probability sample of 1250 schools and 6000 teachers in grades 1-12, is the 1993 National Survey of Science and Mathematics Education. See I. Weiss, "The Status of Science and Mathematics Teaching in the United States: Comparing Teacher Views and Classroom Practice to National Standards." *NISE Brief* (University of Wisconsin-Madison), 1 (June 1997): 1-8. A new U.S. Department of Education report, "Teacher Quality: A Report on the Preparation and Qualifications of Public School Teachers," based on a national survey of 4000 veteran and new teachers of all subjects (not just math and science) confirms these results. See J. Basinger, "Most New Schoolteachers Feel Unprepared for Recent Demands of the Classroom, Survey Finds." *The Chronicle of Higher Education*, Jan. 29, 1999, and <www.nces.ed.gov/pubsearch/pubsinfo.asp?pubid=1999080>

[†] In 1996, a sample of 930 recipients of Presidential Awards for Excellence in Mathematics and Science Teaching, bestowed annually since 1982 on a mathematics teacher and a science teacher at the secondary

Likewise, professional development – intensive and rigorous, with follow-up – can overcome flaws in content and pedagogical training. Recently, a decade-long study clearly established the links among professional development, changes in teaching practice, and improved student achievement in California.[19] But school districts should not be left to shoulder the burden of training that undergraduate education failed to deliver. This becomes an expensive form of compensatory teacher education – and a diversion of scarce resources that could be put toward much-needed merit-based salary increases for teachers, the purchase of new materials and classroom equipment, and ongoing professional development.[*]

As another commentator notes, it is important to connect professional development to the evaluation of teachers and to student performance:

> The disconnect between professional development and growth-oriented performance appraisal is hard-wired into prevailing practice, if not into collective bargaining agreements. Few principals align their evaluations of teachers with expected competencies addressed through professional development. . . . What's good for students should be good for our teachers. In schools, professional development must be viewed as part of a comprehensive system . . . that supports teachers and administrators in continually improving their proficiency with respect to specific competencies linked to student-learning outcomes.[20]

Without instructional quality control, motivating students to learn to world-class standards is futile. But teacher-strapped districts are apt to sacrifice quality for quantity – more experience for less salary – in hiring. State agencies routinely issue temporary,

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level from every State and U.S. territory, was surveyed for the first time. The findings showed that over 70 percent of the high school Awardees had majored in a science discipline, compared to 54 percent nationally. Awardees in mathematics similarly majored in math in a proportion well beyond the national average (55 v. 39 percent). This survey was sent to 1390 Awardees with at least 15 years of teaching experience, yielding an 82 percent response rate. See I. Weiss and J. Raphael, *Characteristics of Presidential Awardees: How Do They Compare with Science and Mathematics Teachers Nationally?* (Chapel Hill, NC: Horizon Research, Inc., 1996).

[*] For example, testimony at the NSB field hearing May 29, 1998, in Los Angeles on informal science learning indicated that museums and science centers are deeply involved in professional development of science teachers employed by districts in their proximity. This connection of the formal and informal systems is neither well-recognized nor systematically exploited. See especially the keynote address of the Executive Director and CEO of the L.A. Natural History Museum, James L. Powell, <www.nsf.gov/nsb/meetings>.

emergency, and provisional licenses.[*] The challenge of recruiting and retaining well-prepared teachers bumps up against other considerations, including reduced class size, which requires more teachers, straining the already limited supply of those with significant content background in mathematics and science.[†] A simultaneous increase in student enrollment levels and teacher retirements will increase the pressure to hire unqualified teachers.[21]

Only the resolve of all partners who contribute to the training, certification, hiring, evaluating, and professional development of math and science teachers will reduce "out of field" teaching.[‡] Then those with solid grounding in these subjects will have to confront the quandary of career choice – alternative sources of attractive employment opportunities. For districts to compete with these opportunities, as the NSB stated in July, communities must build "a system of rewards and incentives, including appropriate salaries, for well-trained teachers who are knowledgeable about content and pedagogically skillful." Ideas worth pursuing include: forgivable student loans and state income tax credits for new teachers with content certification, creation of a national job bank to assist school districts in locating teachers with the desired mathematics or science and grade level credentials, and awarding merit raises for the acquisition by teachers of specific skills and content concentrations.[*]

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[*] Some governors favor incentives to attract and retain qualified teachers. See, for example, "Taft Targets Math, Science Testing," *Columbus Dispatch*, Sept. 3, 1998. Voluntary certification through the National Board for Professional Teaching Standards is expected to grow as the districts coalesce on the implementation of content standards for students in core subjects (see <//www.nbpts.org>). It is germane here as well that references to the command of modern technology as a teaching necessity are barely visible in the education literature, with computer-aided instruction hardly seen as a mainstream tool in teacher preparation (see below).

[†] There has been much "political caterwauling about class size" (see L. Monteagudo, "MORE Teachers? What About the Ones We Have Now?" *Education Week*, Jan. 13, 1999: 72). Indeed, most new funding – over $1 billion – for education in the FY 1999 budget was designated for hiring new teachers to reduce class size. But any gain in individual student attention derived from reducing class enrollment from 22 to 17 will be nullified by that teacher's lack of content knowledge. As Monteagudo notes, "Especially in rural and inner-city areas, it is already hard enough to attract strong applicants. By earmarking Federal funds for hiring additional teachers as opposed to investing in the ones we have in place now, we are placing an even greater burden on those districts."

[‡] L. Pearlstein, "Schools Cautioned on Hasty Hiring," *Washington Post*, Sept. 16, 1998, p. A12. Education Secretary Riley is quoted as saying, "Too many school districts, I am afraid, are sacrificing quality for quantity in order to meet the immediate demand of putting a warm body in front of a classroom." More recently, the Secretary has been more blunt in challenging higher education institutions to make teacher preparation a priority, stating "Our colleges of education can no longer be the sleepy backwaters that many of them have been. There must be greater collaboration from all parts of the university community, including the arts and sciences." Quoted in J. Basinger, "College Presidents Must Lead Effort to Improve Teacher Training, Education Chief Says," *The Chronicle of Higher Education*, Feb. 17, 1999. Related to this are the National Council for Accreditation of Teacher Education draft standards that would hold education programs responsible for the quality of their graduates' teaching. See "Draft Standards Issued for Teacher Education," *The Chronicle of Higher Education*, Feb. 5, 1999: A38.

These factors create contradictory pressures for states and local districts. Convergence on what a science or mathematics teacher at the elementary, middle, and secondary level must know and be able to do in the classroom will be a key factor in resolving some of these contradictions.[†]

Recommendation 2: To implement the core recommendation through teacher preparation and professional development:

i. ***The NSB urges formation of three-pronged partnerships: institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts. These partnerships should form around the highest possible standards of subject content knowledge for new teachers, and aim at aligning teacher education, certification requirements and processes, and hiring patterns.***

ii. *Mechanisms for the support of teachers, such as sustained mentoring by individual university mathematics, science,*

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[*] Monetary incentives are endorsed not only by the president of the National Education Association, but also by the Committee on Science of the U.S. House of Representatives. See B. Chase, "Why Not the Best Teacher?" *Washington Post*, Sept. 20, 1998, p. C5; *Unlocking Our Future: Toward A New National Science Policy*. A Report to Congress by the House Committee on Science, Sept. 24, 1998 <www.house.gov/science/science_policy_report.htm.>; and summarizing the work of Linda Darling-Hammond, director of the National Commission on Teaching and America's Future, A.C. Lewis, "'Just Say No' to Unqualified Teachers," *Phi Delta Kappan*, November 1998: 179-180. The President of the Council for Basic Education reminds us that the reauthorized Higher Education Act offers loan forgiveness to teachers willing to work in inner-city schools for five years. He proposes, as part of strengthening Social Security, waiving the cap on "retirement earnings for anyone involved in teaching or school administration." An incentive could be provided for states to do so as well. See C.T. Cross, "Retirees in the Classroom," *Washington Post*, Dec. 31, 1998: A27.

[†] For example, the U.S. Department of Education's Lighthouse Models of Excellence and NSF's Collaboratives for Excellence in Teacher Preparation program unite mathematics and science departments with colleges of education and local school districts in preparing content-based teachers. These programs, the Department's Eisenhower Professional Development Program, NSF's Local Systemic Change Initiatives, and other tools for teacher training are described in U.S. Department of Education and National Science Foundation, *An Action Strategy for Improving Achievement in Mathematics and Science*, Report of an Interagency Working Group, February 1998 (Arlington, VA: NSF 98-79), appendix 4.

> *and education faculty, as well as other teacher support mechanisms such as pay supplements for board certification, should be implemented through the three-pronged partnerships.*

Ensuring the best possible teachers for our schools poses a formidable policy dilemma: how to juggle competing pressures on besieged districts, schools, and classroom teachers?[22] The community partners of schools – higher education, business, and industry – share the obligation to heighten student achievement. A combination of support for strong content and pedagogical preparation of teachers, continuing professional development linked to classroom performance and improved student achievement, and incentives that keep good teachers in the classroom provides an avenue for acting – in the name of accountability – upon that obligation.

Another avenue, using categorical Federal education programs such as Title I for poor children, would increase incentives for educators or students to do well.[23] One option, for example, would make improved performance part of the standard for payment under Title I, a provision that could be built into the Elementary and Secondary Education Act that is subject to reauthorization in 1999.

C. *College Admissions*

Quality teaching and learning of mathematics and science bestows advantages on students. Content standards, clusters of appropriate courses, and graduation requirements illuminate the path to future advantages. They smooth the transition to college and the workplace by forming a foundation for later learning and drawing students' career aspirations within reach. But how high schools assess student progress has consequences for deciding who gains access to higher education and, moreover, who is prepared to succeed at the baccalaureate level and beyond. Congruence between what is needed to *exit* secondary education and *enter* higher education would be ideal. Because the metrics for each leave much to chance, how to define and predict student "success" remains a matter of contention.

Longitudinal data on 1982 high school graduates point to the role of course-taking or "academic intensity," as opposed to high school grade point average or SAT/ACT scores, in predicting completion of baccalaureate degrees. (Academic intensity refers to trigonometry, precalculus, and calculus, as well as laboratory science, especially chemistry and physics). By 1993, only 42 percent of black students who had gone directly into four-year colleges and universities had received the baccalaureate as compared to 72 percent of white students in the cohort.[*]

An education researcher recently observed,

> Grades are a crapshoot, varying wildly from teacher to teacher and from school to school; a single standardized-test score is merely a snapshot of a student's performance on a Saturday morning. But a student invests years in a course of study, which provides momentum into higher education and beyond. The effects of grades and tests diminish in time, but the substance of learning does not go away. . . . [So] which of these indicators – grades, scores, or courses – would you rather rely on in admissions decisions? In which area does achievement seem to be most meaningful for students' success? And which can educators change most easily? The student's course of study wins, hands down.[24]

Nevertheless, short-term and readily quantifiable measures such as standardized test scores tend to dominate admissions decisions. Such decisions promote the participation of some students in mathematics and science, and discourage others.[†]

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[*] "Controlling for socioeconomic status, high school curriculum is 48 percent more accurate than test scores and 72 percent more accurate than class rank or grade-point average in predicting whether a student will get a bachelor's degree." C. Adelman, "Forget What Color You Are, It's Where You Went to School." *Washington Post*, Nov. 2, 1998: A19.

[†] The NSB Committee on Education and Human Resources has defined for further examination in 1999 the issue of standardized tests, especially the SAT and the GRE, in the college and graduate school admissions processes. The NSB study will build on W.G. Bowen and D. Bok, *The Shape of the River: Long-Term Consequences of Considering Race in College and University Admissions* (Princeton, NJ: Princeton U. Press, 1998); commentary such as "Elite Colleges' Race-Sensitive Policies Opened Doors to Black Success, Says Broad New Study, *The Chronicle of Higher Education*, Sept. 9, 1998 <//chronicle.com/daily/98/09/98090901n.htm>; E. Bonner, "Study Strongly Supports Affirmative Action in Admissions to Elite Colleges." *New York Times*, Sept. 9, 1998: B10; W.G. Bowen and D. Bok, "Get In, Get Ahead: Here's Why." *Washington Post*, Sept. 20, 1998: C1; and S.M. Malcom et al., *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans* (Washington, DC: American Association for the Advancement of Science, 1998).

Data suggest that the cumulative disadvantages of family income will be compounded by admissions criteria that apply the wrong filters and restrict opportunities.[*] For example, nearly 60 percent of low-income nonattending students cite an inability to afford college as the reason.[+] If preparation is the key to college access and enrollment, then we must find ways of reducing the achievement gap in high school performance between majority and minority students. There is new evidence that, even in suburban schools where family income and per pupil spending is high, peer pressure may suppress minority student performance.[25] This would suggest that out-of-class influences, which are less amenable to policy intervention, have pernicious effects on achievement.

Students simply face different classroom experiences due to factors unrelated to interest or ability. Recent studies suggest that "successful theories will probably have to look more carefully at the way black and white children respond to the same classroom experiences, such as being in a smaller classroom, having a more competent teacher, having a teacher of their own race, or [one] . . . with high expectations for those who perform below the norm for their age group."[26] The President of the National Education Associate writes: "Until large numbers of students in the *same* school and the *same* neighborhood value academic achievement, success will continue to be the exception . . . If universities and urban public schools could become 'sister cities,' our most troubled schools might be saved from *within*."[27]

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[*] The National Education Longitudinal Survey of 1988 shows that among those who scored in the top third of a standardized test, low-income students were five times more likely to skip college as were high-income students. Students who took advanced mathematics and science courses were more likely to attend college than those who didn't, but low-income students lagged their high-income peers. "Money, More Than Brains, Governs Whether Students Will Attend College, Study Finds." *The Chronicle of Higher Education*, Aug. 10, 1998 <//chronicle.com/daily/98/08/98081003n.shtml>.

[+] A quarter of these students' parents claim an inability to get financial aid information when their child was in 8th grade and they were deciding whether college would be affordable. A quarter also reports that they did not apply for financial aid because they did not know how to do so. Information on the financial aid process must reach families early; the end of high school may be too late. Institutions of higher education are also revising their financial aid policies to attract more students from low- and middle-income families. See "Change in Aid Policy Nets Princeton More Students From Low- and Middle-Income Families." *The Chronicle of Higher Education*, Aug. 14, 1998 <//chronicle.com/daily/98/08/98081402n.htm>.

For university faculty to embrace collaboration with schools and K-12 educators, there must be some incentive for spending professional time in support of a community partner.[28] A Southern Education Foundation report lauds some state efforts to create a "seamless" education system: K-12 schools and colleges work together to set standards and curricula, and to hold colleges accountable – much as schools already are – by tying state resources to performance on a set of indicators, including the status of minority students.[29] In this spirit, it has been hypothesized that:

> States and school districts are reluctant to pursue reforms more aggressively until they are sure higher education admissions and placement processes will accommodate their students. The result is stasis: Both sides are waiting for the other to pull the "trigger." We must adjust, and even overhaul, the current melange of K-16 education policies that sends confusing signals to students and schools about what knowledge is worth knowing. Universities must collaborate with K-12 leaders and policymakers to improve policies that will enhance academic preparation, elevate education standards, and let prospective college students know what lies ahead.[30]

Recommendation 3: ***To implement the core recommendation through the college admissions process, the NSB urges:***

i. ***institutions of higher education to form partnerships with local districts/schools that create a more seamless K-16 system, increasing the congruence between high school graduation requirements in math and science and undergraduate performance demands; and;***

ii. ***faculty and student incentives that motivate interactions to reveal linkages between classroom-based skills and experiences and the demands on thinking and learning in the workplace.***

In the July statement, the NSB exhorted stakeholders to establish "college admissions criteria that reinforce high standards in K-12 education and bolster participation of all students in mathematics and science." Acting as "all one system" means that the strengths and deficiencies of one educational level are not just inherited by the next. Instead, they become spurs to better preparation and the opportunity for higher learning.

By committing university resources to offering programs for middle and high school students, supplying mentors for teachers, etc., higher education provides glimpses at what preparation for college and advanced learning means.[*] Partnering demands adjusting the institutional reward system to recognize such service as instrumental to the mission of the university.

IV. How Research Can Better Inform Practice

The role of research and evaluation in informing – and changing – education practice has itself become a policy issue.[†] Making research reliable, timely, and relevant to classroom teaching and learning has long been a concern of policymakers, educators, and researchers alike. Public awareness of this need has grown as "high standards" are translated from a concept into high-visibility efforts to challenge students, teachers, parents, and communities – and hold all accountable for academic achievement.

The U.S. Department of Education's National Center for Education Statistics (NCES) has sought to develop a moving picture of how well American schools and their students are faring.[31] The National Assessment of Educational Progress (NAEP) compares the performance of today's students with performance by their age peers in the past. Policymakers, business leaders, and parents increasingly ask if American students are achieving academically as much as they can. International comparisons such as TIMSS provide a "world" benchmark for gauging achievements.[32] The NSB's own *Science and Engineering Indicators 1998* report summarizes, in addition to TIMSS and NAEP, robust time series since the 1970s on the performance of 9-, 13-, and 17-year-olds in mathematics, science, and other subjects.[33]

The need for research on practice relates, too, to differing expectations of stakeholders. What do they seek to learn and how best can data be used to refine system-, school-, and classroom-level practice? Some caution that education interventions alone will not suffice.[34] Others seek education investments different in magnitude and kind.[*] A topic for continuing debate within professional communities, among parents, and by policymakers, for example, remains *which* tests should be used for gauging progress in teaching and learning – and for other purposes of teacher and school accountability. A broader topic is ways and styles of learning in both formal and informal settings – how do children learn with understanding and refine the quality of their thinking?[35] No research area than cognitive development is more multidisciplinary or longitudinal in approach.[†] Finally, studies of systemic change are needed: " ... as efforts to reform the elementary and secondary system expand, new indicators of governance, partnerships, and alignment among various parts need to be developed, and research on the measurement of learning of science and mathematics must be extended into undergraduate education."[36]

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[*] Recently, the NSB Committee on Education and Human Resources held a field hearing to explore models for creating such a seamless system. See *All One System: Developing Human Capital and Infrastructure for Science and Engineering*, San Juan, Puerto Rico, Oct. 7, 1998 <www.nsf.gov/nsb/meetings/1998/fieldoct/fieldoct.htm>. For appraisals of the "statewide systemic" approach, see J. Mervis, "Mixed Grades for NSF's Bold Reform of Statewide Education," *Science*, 282, Dec. 4, 1998: 1800-1805.

[†] For example, see N. Lane, Assistant to the President for Science and Technology, "Educational Technologies: How Will We Know They're Working?" 1998 Educational Technology Leadership Conference, Council of Chief State School Officers, Washington, DC, Nov. 12, 1998 (typescript).

Clearly, an agenda such as the one examined in this report is a cogent justification for research: what do we need to know and how best can we engender reliable and usable knowledge?[‡] What organizational arrangement would attract the participation of the requisite research communities? How can an interagency portfolio of basic and applied research that goes beyond extant programs be devised?[37]

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[*] Two reports are noteworthy: National Science and Technology Council, Committees on Fundamental Science and on Health, Safety, and Food, *Investing in Our Future: A National Research Initiative for America's Children for the 21st Century* (Washington, DC: OSTP, April 1997), which recommends research focused on, among other topics, learning, influence of families and communities on development, longitudinal studies, and policy; and *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States*, March 1997 <www.whitehouse.gov/WH/EOP/OSTP/NSTC/ PCAST/k-12ed.html>, which calls for at least 5 percent of all public K-12 education spending in the U.S. (or approximately $13 billion annually in constant 1996 dollars) to be designated for research – a significant increase over the current level of 1.3 percent. (Note: The FY 1999 Federal investment in K-12 education exceeds $15 billion.)

[†] A massive Federal initiative to track children's learning and development from birth, and again from the start of school, was launched in Fall, 1998. One NCES study will test 21,000 kindergartners in 1000 public and private schools and interview their parents and teachers. Another interagency effort called the Early Childhood Longitudinal Study will begin in 2000 by following 12,000 newborns through their 6th birthdays. Both studies will help to distinguish empirically the large learning gaps among children when they enter school and how and why those gaps often persist through high school. See D. Viadero, "NCES Launches Broad Study on Early Childhood," *Education Week*, Dec. 16, 1998 <//www.edweek.org/ew/current/1[illegible]nces.h18>.

[‡] In 1991, the independent National Academy of Education outlined a national research agenda for sparking positive changes in schools. The agenda encompassed the main challenges that persist today: active learning over the lifespan; assessment; bolstering achievement of historically underserved, minority, and impoverished groups; school organization; and connection to teachers and teaching. National Academy of Education, *Research and the Renewal of Education*, Project on Funding Priorities for Educational Research (Stanford, CA: Stanford University, 1991), pp. 5-6.

The National Science Board sees research as a necessary condition for improved student achievement in mathematics and science. Further, research is best supported at a national level and in a global context. While student achievement is the "bottom line" for parents, teachers, schools, communities, and policymakers, analysis based on national and international data sources can help to explain the conditions that affect performance.

Recommendation 4: *To implement the core recommendation through research:*

i. *The National Science Foundation and the Department of Education must spearhead the Federal contribution to SMET education research and evaluation.*

In 1999, NCES and NSF will revisit the 4th grade population that performed so well on TIMSS in international competition. TIMSS-R will sample 8th graders who were in the 4th grade in 1995. Through an analysis of teacher and school questionnaires and the administration of a new achievement test linked to TIMSS, TIMSS-R will test the robustness of the TIMSS 4th grade results and allow examination of schooling in the middle grades. Comparative research is a prerequisite for suggesting appropriate responses by systems at any or all – State, district, school, subject, and classroom – levels.[*]

ii. *Overall, the investment should increase – by the Federal government, private foundations, and other sponsors – in research on schooling, educational systems more generally, and teaching and learning of mathematics and science in particular.*

In 1997, both NSTC and PCAST recommended not only a larger investment, but also a larger-scale program of rigorous, systematic research on education to demonstrate the efficacy of transferring exemplary practices among our nation's schools.[*] The National Science Board endorses research that can generalize to a diversity of classrooms, student populations, and school districts.[†]

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[*] Study designs such as TIMSS-R hold great potential for specifying teaching and learning linkages among curriculum materials, school organization, classroom practices, and student achievement among a sample of 8th grade U.S. students. Such research includes efforts like the First in the World Consortium in northwest suburban Illinois that paid to participate in TIMSS to gauge its students' progress against that of other "countries" of the world. See OERI, U.S. Department of Education, "Seminar on The First in the World Consortium," Aug. 20, 1998, unpublished notes, and <www.ncrel.org/fitw>.

> iii. *To focus and deepen the knowledge base, an interagency Education Research Initiative, led by NSF and the Department of Education, should be implemented. It should be distinguishable as a joint venture within the agencies' respective research missions, and cooperatively funded.*

An experimental program of research is particularly needed on *how* information and computer technologies influence the processes of teaching and learning of science and mathematics by children of various ages and in different classroom settings.[‡] Harnessing the creativity and power of innovative tools and pedagogy should be a priority.

Research on "what works" should thus inform those seeking a change in practice and learning outcomes. The dissemination and adaptation of research results, however, pose other problems. The knowledge base is thin; gaps abound and what is known from empirical study is *not* – even in this age of electronic communication and information retrieval – conveniently catalogued, updated, advertised, and/or accessible to the so-called end-users in schools. Research simply remains outside the purview of most classroom teachers.[*]

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[*] Through workshops with researchers from various communities held in September 1998, advice on a research agenda for teaching and early learning of mathematics, science, and reading (the latter with the participation of the NIH's National Institute of Mental Health) was solicited on developing a Request for Proposals in FY 1999. OSTP and OMB are spearheading this collaboration for a 5-year initiative that will produce measurable outcomes of progress through various research and evaluation designs.

[†] More generally, results of competitively funded research can only inform future investments by districts and local schools, and guide policymakers' decisions about "what works," if they are evaluated to determine the cost and learning effectiveness of scaling up to serve more students. "Randomized field trials," a staple of medical research but seldom employed to test education reforms, allows investigation of a "treatment" randomly assigned to two groups. If the groups are sufficiently similar, then differences in average outcomes of the treatment can be attributed to exposure of the factor under investigation. See P.E. Peterson, "Rigorous Trials and Tests Should Precede Adoption of School Reforms," *The Chronicle of Higher Education*, Jan. 22, 1999: B4.

[‡] Limited national data are equivocal, suggesting that with some students new technology is being used for the same old drill-and-practice in mathematics; yet in the hands of technology-trained middle school teachers, computers can enhance academic performance. See J. Mathews, "Study Faults Computers' Use in Math Education," *Washington Post*, Sept. 30, 1998: A3; E. Bonner, "Computers Help Math Learning, Study Finds," *New York Times*, Sept. 30, 1998, <www.nytimes.com/library/tech/98/09/biztech/articles/30math.html>; and A. Fisher, "High Tech, High Grades?" *Popular Science*, January 1999: 64-69.

Like other professionals, teachers need support networks in various forms – Internet bulletin boards, websites, in-person professional development experiences, university faculty mentors, etc. – to refine their knowledge and skills. Technical assistance by those who understand classroom settings and have the confidence of teachers is essential. In short, "getting the word out" only begins a process of using knowledge to inform ongoing teacher preparation and education practice.

Above all, we should remain mindful that "schools reflect society far more than they shape it, and that test scores tell us much more about what schools are facing than how they're failing. Surely, we must challenge teachers and administrators to do their utmost, but not to work miracles. And not by themselves."[38]

V. Conclusions

The Nation's concern for excellence in K-12 and undergraduate teaching and learning environments is magnified by time: it takes time for any system and the organizations within it to adapt to emerging needs and mounting pressures. We cannot expect instant results.

While the national education goals set by the governors in 1989 will not be realized on the envisioned timetable, the momentum for lifting student performance is unquestioned. Today we take as axiomatic that improved student performance will be short-lived if the conditions for schooling do not change. "To have any real effect, standards must be incorporated into the life of the school: They must be embraced by the students who must learn them, and embraced by the business community and colleges who must make informed decisions about whom to invite into their ranks."[39] The key to energizing education *systems* throughout the Nation is consensus on content standards for the teaching and learning of mathematics and science. This leaves much room for choice and diversity of process and pedagogy, while reinforcing a common market of demand for the skills that will dominate the 21st century workplace.

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[*] Polls show, not surprisingly, that local schools in turn fail to provide parents with enough information to make them advocates for what their children are expected to know. These are the same people who simultaneously support rigorous content standards but are intimidated by them. See A.D. Coles, "Parents Ill-Informed About Standards, Poll Finds," *Education Week*, Oct. 28, 1998: 6.

Through recommendations for implementing content-based materials, teaching, college admissions, and other practices informed by research, the National Science Board affirms that there is no greater national need than equipping the next generation with the tools of the workplace and citizenship. This will require a greater consensus among stakeholders on the content of K-16 teaching and learning. High expectations will not suffice in raising achievement in mathematics and science; neither will a single-minded emphasis on teachers, curriculum, assessment, or technology.

A generation ago, the NSB Commission on Precollege Education in Mathematics, Science and Technology advised: "Our children are the most important asset of our country; they deserve at least the heritage that was passed to us . . . a level of mathematics, science and technology education that is the finest in the world, without sacrificing the American birthright of personal choice, equity and opportunity."[40] The health of science and engineering tomorrow depends on improved mathematics and science preparation of our students today. The national interest is now a national imperative. We must see educational excellence as a shared responsibility and, above all, a tractable challenge to us all.

ENDNOTES

[1] D.J. Hoff, "With 2000 Looming, Chances of Meeting National Goals Iffy," *Education Week*, Jan. 13, 1999: 28-30, quote at 28.

[2] For details on TIMSS methodology and findings, see W.H. Schmidt et al., *Characterizing Pedagogical Flow: An Investigation of Mathematics and Science Teaching in Six Countries*. Dordrecht, The Netherlands, Kluwer Academic Publishers, 1996; National Center for Education Statistics, *Pursuing Excellence: A Study of U.S. Fourth-Grade Mathematics and Science Achievement in International Context*. Washington, DC: U.S. Department of Education, June 1997 (NCES 97-255); and I.V.S. Mullis et al., *Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study*. Chestnut Hill, MA: TIMSS International Study Center, February 1998. The Commissioner of Education Statistics has also responded to criticisms of the TIMSS methodology and interpretation of findings. See Center for Education Reform and Empower America, *Achievement in the United States: Progress Since A Nation at Risk?* Washington, DC, National Center for Education Statistics, U.S. Department of Education, April 3, 1998: 11 <http://nces.ed.gov>.

[3] The following is distilled from W.H. Schmidt, Executive Director, U.S. National Center for TIMSS, presentation to the National Science Board, May 7, 1998. Also see G.A. Valverde and W.H. Schmidt, "Refocusing U.S. Math and Science Education," *Issues in Science and Technology* (Winter 1997-98): 60-66; and W.H. Schmidt and C.C. McKnight, "What Can We Really Learn from TIMSS?" *Science*, 282, Dec 4, 1998: 1830-1831. These characteristics appear to be necessary, but not sufficient conditions for high student performance.

[4] National Science Board, *The Federal Role in Science and Engineering Graduate and Postdoctoral Education* (Arlington, VA: Feb. 26, 1998, NSB 97-235); and K. Olson, "Despite Increases, Women and Minorities Still Underrepresented in Undergraduate and Graduate S&E Education," *SRS Data Brief*, Jan 15, 1999, NSF 99-320.

[5] U.S. Department of Education, National Center for Education Statistics, *The Condition of Education—1995*, Indicator 46: Student Mobility <//nces.ed.gov/pubs/ce/c9546a01.html>.

[6] American Association for the Advancement of Science, *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology* (Washington, DC: AAAS, 1990); National Council of Teachers of Mathematics, *Curriculum and Evaluation Standards for School Mathematics* (Reston, VA: NCTM, 1989); National Council of Teachers of Mathematics, *Professional Standards for Teaching Mathematics* (Reston, VA: NCTM, 1991); and National Academy of Sciences, National Research Council, *National Science Education Standards* (Washington, DC: National Academy Press, 1996). At a White House "Education Announcement/Roundtable" on April 2, 1997, the President remarked that "240 companies have endorsed this national standards movement" <http://library.whitehouse.gov/cgi-bin/>. NCTM is currently revising and updating the mathematics standards. A draft is available for public comment at <www.nctm.org/standards2000/>.

[7] See Education Week, *Quality Counts* (January 22, 1997).

[8] C.T. Cross, "The Standards War: Some Lessons Learned," *Education Week*, Oct. 21, 1998 <//www.edweek.org/ew/current/08cross.h19>

[9] K.K. Manzo, "Report for Goals Panel Calls for Consensus on Standards," *Education Week*, Sept. 9, 1998 <www.edweek.org/ew/current/01stand.h18>. Also see K.K. Manzo, "Think Tank Inks Blueprint to Lift Achievement," *Education Week*, Nov. 18, 1998: 6, reporting on the Consortium on Renewing Education's *20/20 Vision: A Strategy for Doubling America's Academic Achievement by the Year 2020*.

[10] M.S. Tucker, "The State of Standards: Powerful Tool or Symbolic Gesture?" *Expecting More* (Newsletter on Standards-Based Reform), 1 (Spring 1998): 2.

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[11] Education Week. *Quality Counts '99* (January 11, 1999) <www.edweek.org/sreports/qc99/exsum.htm>

[12] P. Black and D. Wiliam. "Inside the Black Box: Raising Standards through Classroom Assessment." *Phi Delta Kappan*. October 1998: 139-148.

[13] American Educational Research Association *Letter*. April 18. 1997.

[14] J. Mervis. "U.S. Tries Variations on High School Curriculum." *Science*. vol. 281. July 10. 1998. pp. 161-162.

[15] D. Rich. "You Can't Teach What You Don't Know." *Education Week*. Sept. 16. 1998 <www.edweek.org/ew/current/02rich.h18>.

[16] "In State of the Union Speech. President Urges Testing of Prospective Teachers." *The Chronicle of Higher Education*. Jan. 20. 1999 <//chronicle.com/daily/99/01/99012001n.html>.

[17] G. Overholser. "To Work on the Schools." *Washington Post*. Sept 16. 1998. p. A17.

[18] S. Tobias. "Some Recent Developments in Teacher Education in Mathematics and Science." *NISE Occasional Paper*. No. 4. April 1997. 2.

[19] D.K. Cohen and H.C. Hill. "State Policy and Classroom Performance: Mathematics Reform in California." *CPRE Policy Brief*. RB-23-January 1998: 10-11.

[20] C. Mojkowski, "Teachers and Standards: Sauce for the Goose . . .," *Education Week*, Jan. 13, 1999: 39.

[21] R.W. Riley, "An End to 'Quiet Backwaters': Universities Must Make Teacher Education a Much Higher Day-to-Day Priority," *The Chronicle of Higher Education*, Oct. 2, 1998: B10. Also see C. Pipho, "A 'Real' Teacher Shortage," *Phi Delta Kappan*, November 1998: 181-182. Also see N. Lane, "The Integral Role of Two-Year Colleges in Science and Mathematics Preparation of Prospective Teachers," *SACNAS Journal*, Summer 1998 <www.sacnas.org/journal/su98/page5.htm>.

[22] See R.L. Linn, "Standards-Based Accountability: Ten Suggestions." *CRESST Policy Brief*, adaptation of Technical Report 490, *Assessments and Accountability*, 1998, available at <www.cse.ucla.edu>.

[23] For example, see "Good Teaching Matters: How Well-Qualified Teachers Can Close the Gap." *Thinking K-16* (A Publication of The Education Trust), Summer 1998: 1-15; and H.J. Walberg, "Incentivized School Standards Work," *Education Week*, Nov. 4, 1998: 48, 51.

[24] C. Adelman. "To Help Minority Students, Raise Their Graduate Rates." *The Chronicle of Higher Education*. Sept. 4. 1998. p. B8.

[25] See M.A. Fletcher, "A Good-School, Bad-Grade Mystery," *Washington Post*. Oct. 23. 1998: A1.

[26] Quote from C. Jencks and M. Phillips. "The Black-White Test Score Gap." *Education Week*. Sept. 30. 1998: 44, 32.

[27] B. Chase. "A Hope in the Unseen." *Washington Post*. Oct. 18. 1998: C5.

[28] For example, see S. Hebel. "Report Urges State Universities to Become Engaged with Their Communities." *The Chronicle of Higher Education*. Feb. 4. 1999 and <www.intervisage.com/Kellogg/STATEMENTS/index.html>.

[29] D. Lederman. "Report Sees Lack of Progress by Southern States in Educating Black Students." *The Chronicle of Higher Education*. Sept. 4. 1998: A57.

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[10] M.W. Kirst. "Bridging the Remediation Gap." *Education Week*. Sept. 9. 1998 <www.edweek.org/ew/current/01kirst.h18>

[11] For example. see The National Center for Education Statistics. *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994. 1990, 1987. and 1982 High School Graduates.* Washington. DC. U.S. Department of Education. 1997 (NCES 97-260).

[12] See and National Research Council. Center for Science. Mathematics. and Engineering Education. *Mathematics and Science Education Around the World – What Can We Learn?* Washington. DC: National Academy Press. 1996; and J.M. Atkin and P. Black. "Policy Perils of International Comparisons: The TIMSS Case." *Phi Delta Kappan*. September 1997: 22-28.

[13] National Science Board. *Science and Engineering Indicators 1998* (Arlington. VA: National Science Foundation. 1998, NSB-98-1). esp. ch. 1.

[14] L. Cuban, "The Myth of Failed School Reform." *Education Week*. Nov. 6. 1995: 41. 51; and J.J. Gallagher. "Education. Alone. Is a Weak Treatment." *Education Week*. July 8. 1998. <www.edweek.org/ew/current/42callag.h17>.

[15] For example. National Academy of Sciences. *How People Learn: Brain. Mind. Experience. and School* (Washington. DC: National Academy Press. March 1999 (forthcoming). Also see Council of Economic Advisors. "The First Three Years: Investments That Pay," White Paper. Apr. 17. 1997.

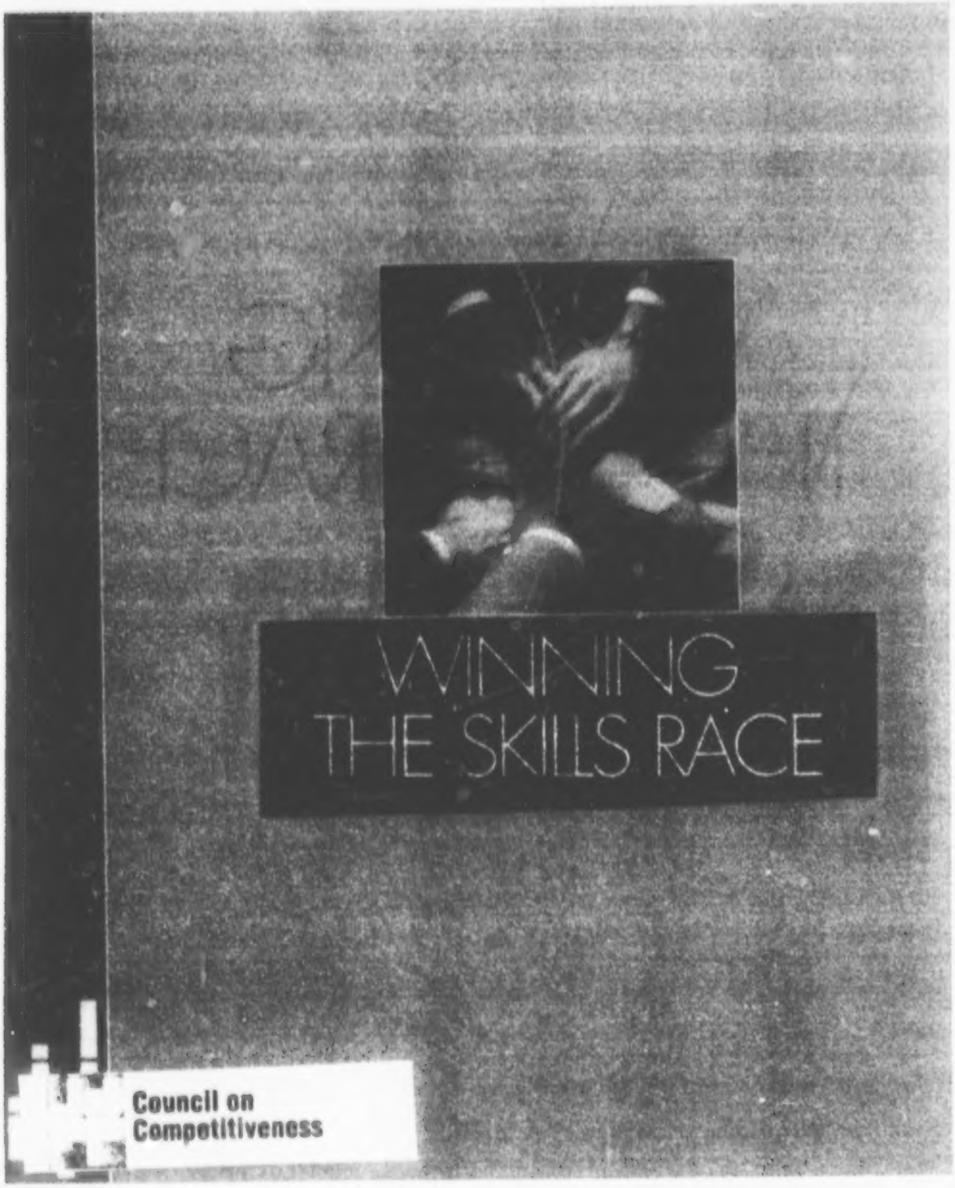
[16] Division of Research. Evaluation. and Communication. Directorate for Education and Human Resources. *Indicators of Science and Mathematics Education 1995*. L.E. Suter, ed. Arlington. VA: National Science Foundation. 1996 (NSF 96-52). p. 109. Also see R.L. Linn and E.L. Baker. "Back to Basics – Indicators as a System." *The CRESST Line* (UCLA Newsletter of the National Center for Research on Evaluation. Standards. and Student Testing), Winter 1998: 1-3.

[17] For example, see M.A. Vinovskis, *Changing Federal Strategies for Supporting Educational Research, Development, and Statistics* (Washington. DC: U.S. Department of Education. National Educational Research Policy and Priorities Board. September 1998), esp. Appendix C.

[18] R. Evans. "The Great Accountability Fallacy." Education Week. Feb. 3. 1999 <www.edweek.org/ew/current/21revans.h18>

[19] S. Pimentel and L.A. Arsht. "Don't Be Confused by the Rankings; Focus on Results." *Education Week*. Nov. 25. 1998: 56. 40.

[20] National Science Board Commission on Precollege Education in Mathematics. Science and Technology. *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics. Science and Technology Education for all American Elementary and Secondary Students so that Their Achievement is the Best in the World by 1995* (Washington. DC: National Science Foundation. 1983. CPCE-NSF-03): v.



WINNING
THE SKILLS RACE

Council on
Competitiveness

WINNING
THE SKILLS RACE

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Council Senior Fellow Amy Kaslow took charge of the project, providing strategic oversight and direction throughout the two-year effort. She and former Council Associate Gretchen Rhines conducted all of the site visits and many other interviews that shaped the final analysis. Ms. Rhines served as a superb day-to-day manager of the project, coordinating visits, researching issues, and refining the end product. Former Senior Fellow Howard Samuel provided essential counsel throughout.

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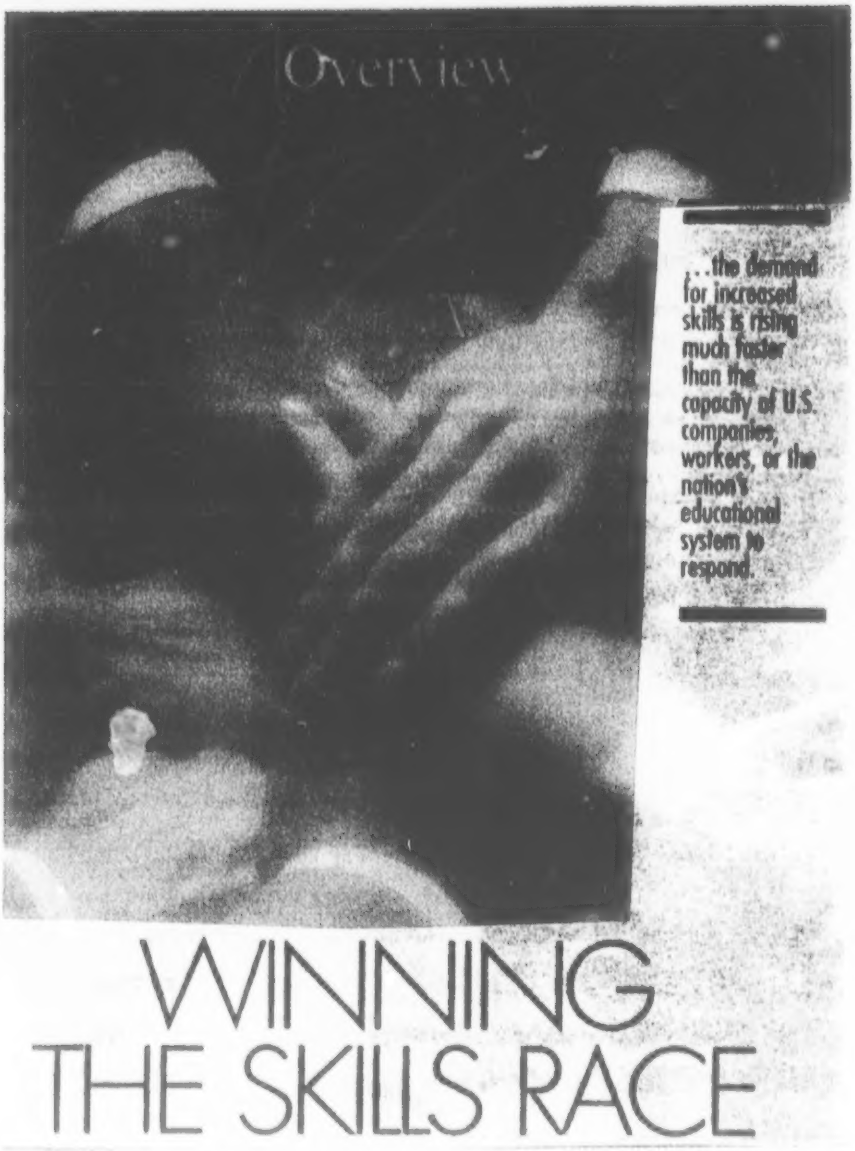


Overview

. . . the demand for increased skills is rising much faster than the capacity of U.S. companies, workers, or the nation's educational system to respond.

WINNING THE SKILLS RACE

191

WINNING THE SKILLS RACE

Overview

.S. prosperity in today's knowledge-driven economy demands the world's most skilled and productive workforce. Members of the Council on Competitiveness have singled out worker skills as the greatest competitive challenge the nation faces over the next decade. Their concern reflects broad recognition among leaders from business, labor, and universities that we face compelling pressures to upgrade the U.S. skills base:

- Information technology has become a defining feature of the American workplace, turning computer literacy into a basic skill requirement and creating a demand for knowledge workers that is not being met.
- Global competition has intensified, increasing the economic premium on high skills and leaving unskilled American workers in an increasingly vulnerable position.
- The aging of the national workforce has produced a massive requirement to replace a generation of skilled wage earners that will reach retirement age by 2005.
- Welfare reform has mandated a move of several million mostly unskilled Americans from public assistance into entry-level jobs over the next five years.

This Council report on upgrading worker capabilities provides fresh insights from across the country on how key stakeholders in workforce preparedness – employers, workers, educators, trainers, and government officials – are responding to the pressure of the skills race. Under the guidance of a Task Force made up of widely respected experts and practitioners, the Council combined focus groups in Washington with more than a year of site visits in the field to companies, labor unions, educational institutions, and nonprofit organizations.

Our research and writing team traveled to every region of the country to search for examples of best practice in community workforce development. They spent hours on the ground with workers, union representatives, trainers, managers, and senior executives in companies large and small. They visited community colleges, private training vendors, and nonprofit workforce alliances. They also met with municipal, state, and federal officials with hands-on responsibility for publicly funded training programs. This distinctive approach has put a human face on a challenge that is national in scope, urgent in character, and too often viewed as an abstraction.

> **...members of the Council on Competitiveness singled out worker skills as the greatest competitive challenge the nation faces over the next decade.**

The Council's firsthand look at efforts to meet the skills challenge validates a simple but fundamental point: the demand for increased skills is rising much faster than the capacity of U.S. companies, workers, or the nation's educational system to respond. Distressing numbers of workers cannot read or do simple math, while the need to upgrade the skills of incumbent workers is outstripping the capacity of virtually all companies. Employers in all industries are scrambling for workers who can adapt quickly to new tasks and new market demands. Workers recognize the link between higher skills and higher wages, but many feel deeply insecure about the pace of change in job requirements. Few can count on spending their careers at one company, and many are struggling to make themselves employable. Community colleges and four-year schools face rising expectations to shorten and sharpen the learning cycle, along with growing demands to provide remedial education. Governments at every level face comparable pressure to streamline public sector training programs and to adapt them to local needs.

Part I of this report provides an overview of the skills challenge. It describes today's crunch as more than the result of tight labor markets — it is structural in origin. If we do not meet the challenge, the economic and social costs will be profound: future growth will be cut; the income gap will widen further; competition for low-skilled jobs will increase; and U.S. companies will look increasingly offshore to meet their high-skill requirements.

Part II examines the impact of the skills shortage on major stakeholders. The build-up of pressure has pushed employers, workers, educators, community leaders, and public officials to cooperate more closely. They have joined forces in areas of shared interest. They are strengthening the transition from school into the workplace, pooling resources to improve the quality and to reduce the costs of training, and responding to market demand for greater access to training and for greater portability of skills. Progress has been uneven, but longstanding walls between employers and schools, schools and workers, and the private and public sectors are gradually breaking down.

Part III looks beyond the trends into the specifics of local solutions to shared problems — approaches that document what works through a rich set of examples from across the country. A number of strategic insights can be distilled from these examples:

- **Collaboration defines best practice in training and education.** No single business, group of workers, educational institution, or government agency can tackle the challenge alone. All parties need to be fully engaged in the design and execution of pace-setting programs: employers provide learning opportunities, workers devote time and energy to learning, and schools teach marketable skills. Collaboration is most likely when employers clearly define their needs, workers have an up-front stake in learning new skills, and providers of training are attuned to market demand.

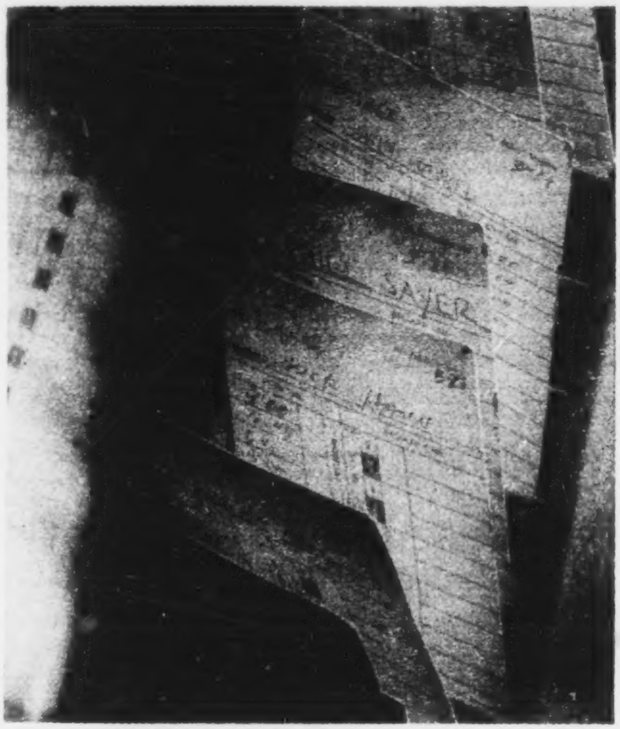
- **Success is most likely when training outcomes are measured and when all parties are held accountable for their performance.** Best practice in community college training, corporate programs, and publicly funded employment and training centers is linked invariably to good metrics and real accountability. These factors produce winning results across the board. Workers gain upward mobility and greater employability; firms gain increased productivity; providers gain revenues; and communities benefit from economic growth.

- **Work-related learning is increasingly job-specific, on-site, and just-in-time.** There is a clear trend away from subject-driven, off-site, classroom-style education and training. Instead, the compression of time puts a greater premium on convenience and customization. Best practice today focuses on providing on-demand training from desktop computers, promoting interactive learning on-site, and shortening the cycle of formal training courses.

- **New learning technologies are transforming education and training by overcoming barriers of time, distance, and availability.** The computer-based and Internet-based tools that are being deployed throughout the United States have vast potential to reduce costs, increase access, and customize the learning process. Best practice allows both employers and workers to tap into resources at their own pace and convenience. But electronic tools are not readily accessible to everyone and are not a cure-all. They must be incorporated into broader strategies of skills development.

- **Outstanding training initiatives anticipate as well as respond to change.** Not all best practice addresses the immediate shortfall in skills. Many notable efforts have been launched to meet over-the-horizon challenges. The imminent retirement of manufacturing workers in the Midwest, the population explosion in the far West, and constantly changing impact of technology on skill requirements are some of the developments that have sparked new approaches. What sets these initiatives apart is their readiness to commit resources now to prepare for future needs.

The Council's inquiry shows collaboration on the rise in every part of the country, especially to bridge the gap between schools and the skill demands of the workplace. Companies, unions, and educational institutions are looking beyond their own immediate needs to exercise leadership in workforce development at the community level. Strengthening the talent pool has become a centerpiece of state-led and community-led growth strategies.



The direction of change may be positive, but its pace clearly is not fast

Strengthening the talent pool has become a centerpiece of state-led and community-led growth strategies.

enough. Despite their pressing needs and the well-documented payoff of investments in skills, employers' spending on formal training lags behind the growth of the workforce on a per capita basis. The costs and risks of training — both for companies that fear loss of investment through early turnover and for workers who wonder what the return will be — still thwart change. Too many individuals and institutions are unaware of how to partner their way to upgrading skills, or are not ready to make the commitment to do so. The temptation to point the finger at others for the skills shortage — shortsighted employers, unmotivated workers, deficient K–12 education, or poorly executed government programs — remains high.

Americans can unite around an action agenda to win the skills race. The Council's assessment of best practice in the field underscores seven items that belong on this agenda:

1) **Build Public Awareness.** A concerted effort to upgrade worker capabilities requires broad public support. Leaders from every sector of the economy should reinforce the message that the United States has a vital stake in workforce preparedness and that collaboration is the most effective way to meet the challenge.

2) **Fill Information Gaps.** Increased collaboration requires labor market information that is timely, accurate, and easily available. Federal and state agencies can contribute leadership and resources, but most information has to be collected and disseminated at the local level. This is where most workers find out about learning opportunities, small companies pool resources, and corporations share their workforce needs with educators, trainers, supplier firms, and potential hires.

3) **Leverage Technology.** World leadership in information technology should give the United States a clear edge in training and education. Internet-based clearinghouses, for example, expand the flow of information to communities around the country on workforce needs, learning opportunities, and best practice. State-of-the-art resources also act as multipliers, increasing the availability of cost-effective, online learning tools, which particularly benefit small and mid-sized firms, the country's most prolific job creators but the lowest spenders on training.

4) **Focus on Metrics.** Training succeeds when employers, workers, educators and government agencies are able to gauge the impact of investment on outcomes. Today's limited efforts to measure results must be vigorously expanded. Good metrics require determined efforts to track the outcome of training on job placement and job performance, as well as the company's bottom line.

5) **Tighten Accountability.** Improved metrics should make it easier to hold providers of training responsible for their performance. Government agencies can tighten accountability through extensive use of performance-based funding. Companies, in turn, can raise the stakes to ensure that in-house training competes with the best available.

6) **Share Best Practices.** Individuals, organizations, and communities all need more exposure to the experience and success of others. Government has a particular contribution to make in benchmarking and sharing best practice in communitywide workforce development. Companies, unions, and community colleges must take the lead on a peer-to-peer basis to spread the

word on strategies that produce the best results.

7) **Encourage Personal Initiative.** The most effective agents of change in strengthening worker skills are people who reach outside their own organizations to create networks. These initiators ask, "What are my needs? Who shares my concerns? What can I contribute? What resources can I tap?" Every stakeholder in the skills race must find and support a cadre of initiators.

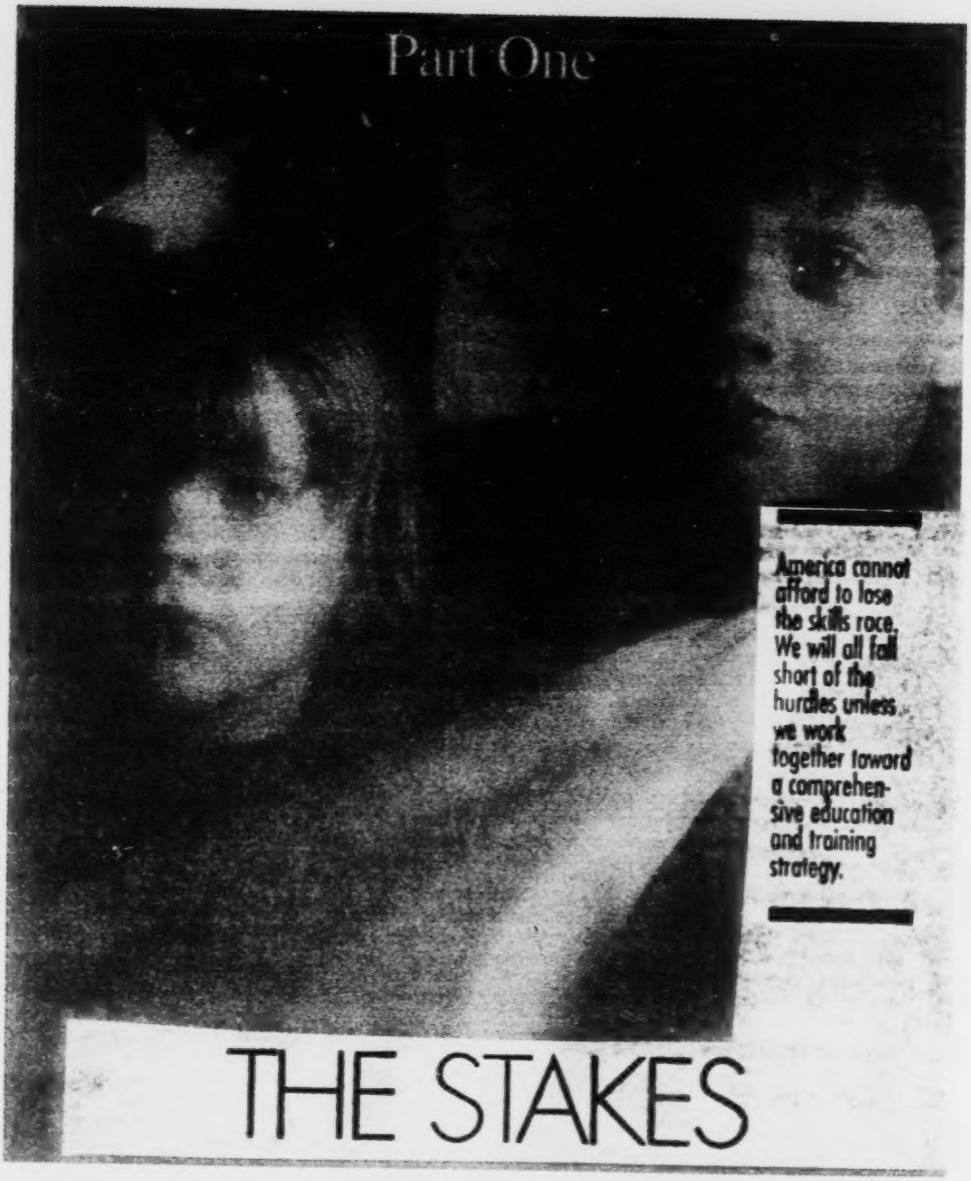
The Council will engage its members and national affiliates over the coming year to move this agenda forward. We will share our findings with public and private sector leaders, gather additional examples of best practice, and publish a profile benchmarking U.S. workforce capabilities. The stakes are high, and the need for greater collaboration has never been more compelling.

Richard C. Notebaert *Ameritech Corporation*	George F. Becker *United Steelworkers of America* *AFL-CIO, CLC*	Harold J. Raveché *Stevens Institute of* *Technology*

Chairmen of Winning the Skills Race

William R. Hambrecht *W.R. Hambrecht & Co., LLC*	Charles M. Vest *Massachusetts Institute of Technology*	Jack Sheinkman *Amalgamated Bank* *of New York*

Chairman and Vice Chairmen of the Council on Competitiveness



Part One

America cannot afford to lose the skills race. We will all fall short of the hurdles unless we work together toward a comprehensive education and training strategy.

THE STAKES

Part One

THE STAKES

Never before has the appearance of working America been so deceiving. With the strong comeback from the relatively high rate of joblessness of the late 1980s and early 1990s, the outlook seems very bright. Record numbers of people are working, and the unemployment rate is the lowest it's been in decades.

But the reality behind the numbers is troubling. There is an acute skills shortage in every part of the country that threatens the foundation of American competitiveness.

Our findings are based on a year of travel across the United States, listening to people in the field talk about their most pressing concerns. Their problems and potential solutions are certainly not limited to any particular place or time. Nor are they restricted to one level of the workforce, or to one specific business. The issues are very real across the spectrum.

- In the Midwest, for example, business is booming, and skilled labor is nowhere to be found. A major employer in Milwaukee, the automation firm **Allen-Bradley**, has been particularly hard-hit. Like many companies across the nation, its workforce is aging; within 10 years an estimated 80 percent of its employees will retire. With an unemployment rate of less than four percent, local labor pools have all dried up. To avoid hemorrhaging, the company is scouring both local and distant schools to find qualified new entrants. The fixation on meeting current labor needs has become management's most absorbing responsibility.

- In parts of the Sun Belt, populations are growing at staggering rates. **US West Communications** is unable to meet service demands in Arizona, Colorado, and Nevada, where many newly built homes have no access to telephone service. With an infrastructure originally designed to meet the needs of a small, rural population, US West cannot keep pace with today's construction rate. The speed of change presents serious training challenges as the company seeks to improve efficiency while simultaneously trying to prosper in a highly competitive industry.

- Nowhere is the bidding war for skilled technicians hotter than in California's Silicon Valley, where some 80 percent of the jobs require specialized learning and basic technical knowledge. What puts those skills at a premium is the constant churning among incumbent workers, who jump to new job opportunities. Hard-pressed companies rely on local educational institutions like **DeAnza College** in Cupertino to continually tailor training programs to transition workers from one job to the next. Whether the courses are conducted on-site at corporate headquarters and plants, offered at the school campus, or available on-line, the learning process is geared toward immediate and practical application in the workplace.

There is an acute skills shortage in every part of the country that threatens the foundation of American competitiveness.

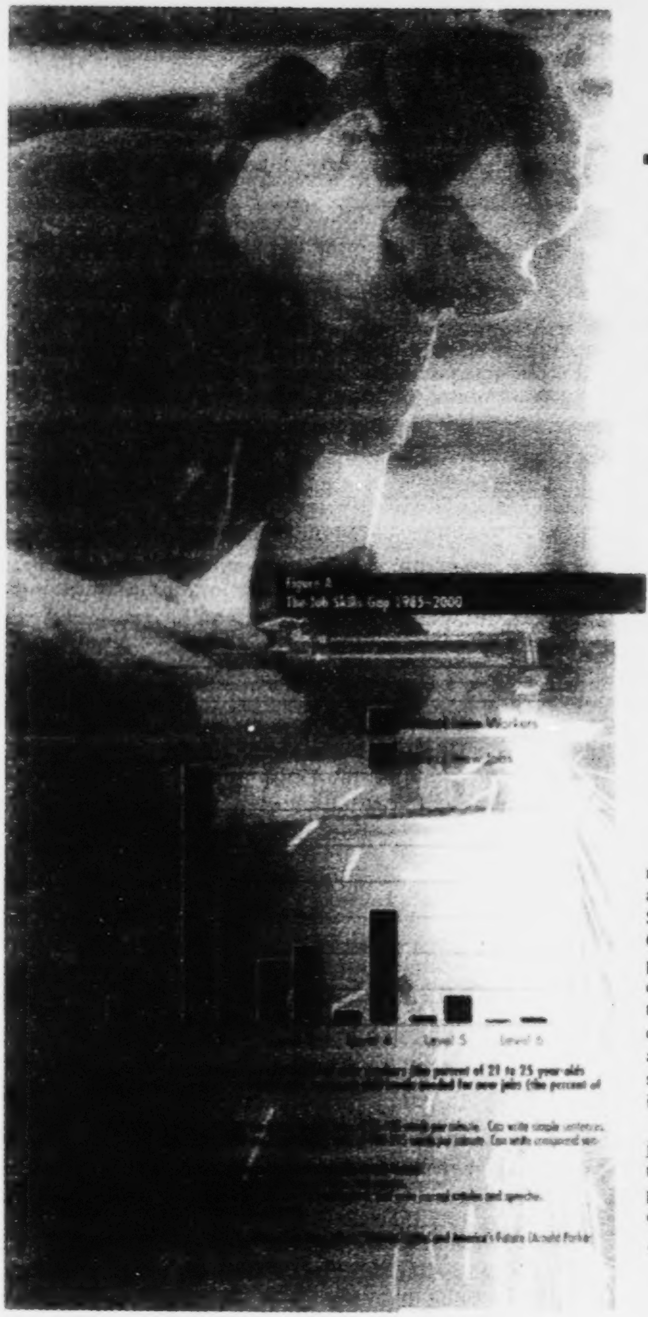


Figure A

The Job Skills Gap 1985–2000

- Service sectors in areas like Orlando, Florida, are scrambling to satisfy massive, short-term hiring needs. Rapid turnover only exacerbates problems for firms like **Walt Disney World Company**, which is hiring thousands of workers, above and beyond its current payroll, to staff its new park and convention center and resort. Around the corner, **Universal Studios** plans to more than triple its workforce (from 6,000 currently to more than 20,000 employees) by 2005. The market is already very tight given the competition for new hires between these two big entertainment companies. But supplier firms and ancillary businesses, growing in response to the big companies' expansion, are competing for much of the same labor. Nearby **Valencia Community College** has turned a potential problem into its own business opportunity by establishing a pipeline of workers through its Hospitality and Tourism Institute. Programs provide on-the-job training to help students move directly into supervisory or mid-management positions in lodging, food service, and tourism.

The skills crunch is not merely the result of tight labor markets. It is deeper and more structural in character. The Schaumburg, Illinois-based **Motorola Corporation** finds only one qualified applicant out of every 10 that it screens for entry-level positions. Even though all of the electronics firm's nationwide applicants have earned high school diplomas, an average of half of them cannot pass seventh-grade math and ninth-grade reading tests.

Motorola is hardly alone. The national job picture shows an American workforce that is not prepared: almost a fifth of employees in the United States have a zero or minimal literacy level in reading and

Source: Fig. A: The Hudson Institute and U.S. Department of Labor.

math, two skills essential for workplace success.[1] The outlook is no better for the majority of new graduates, who leave the nation's high schools without a solid foundation in academics. Now, and for the foreseeable future, there is and will be a premium on the ability to read manuals, technical journals, and financial reports and to write business letters, factual reports, and other detailed accounts. Yet almost 80 percent of new workers cannot write even the most rudimentary reports or read the simplest of instructions.[2] *(See Figure A.)*

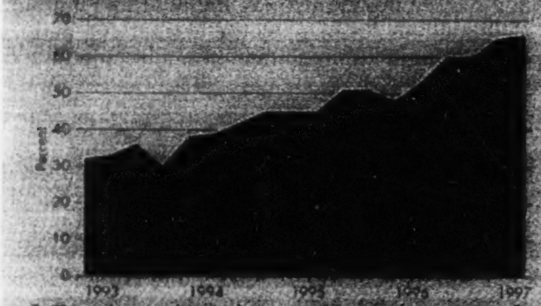
Corporate America is well aware of the challenges ahead. In 1997, twice as many corporate leaders pointed to the skills shortage as the number one barrier to growth, compared to the number of respondents in 1993. *(See Figures B and C.)*

The limitations are not restricted to the low-end of the workforce. Companies across the board are struggling to find skilled hires. One of the most acute examples is in the information technology industry. Payrolls in U.S. computer and software companies, for example, have practically tripled in the past decade, and their demand for personnel continues to explode. But the dearth of qualified workers can be found in a wide range of businesses outside of information technology.

Limited choices have forced many employers to venture overseas for foreign workers with technology skills. Some 144,000 workers in "specialty" categories — primarily skilled technicians — immigrated to this country in fiscal year 1996. According to data from the Immigration and Naturalization Service and the American Electronics Association, they accounted for about half of the nation's overall increase in technology jobs last year.[3] Unless U.S. firms can create "home-grown" technicians, by increasing adult training opportunities and by expanding

Figure B

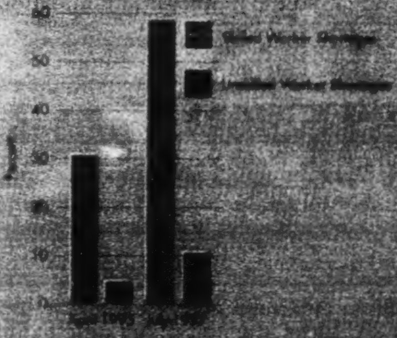
CEOs Who Say Lack of Skilled Workers Is Number One Barrier to Growth



The CEOs surveyed represent product, service and [illegible] companies [illegible] from approximately $1 million to $50 million in [illegible].

Figure C

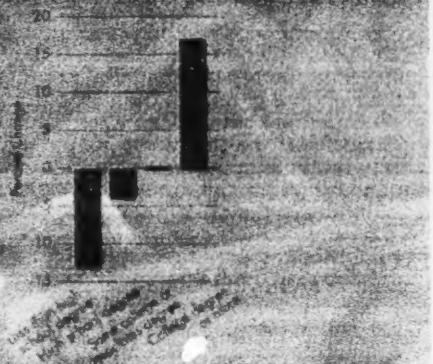
Percent of Companies Reporting...



Source: Fig. B: Coopers & Lybrand L.L.P. survey of growth-company chief executives. Fig. C: National Association of Business Economists.

Figure D

Education Matters More: Growth in Mean Family Income by Educational Attainment of Householder Over the Age of 25, 1979–1996



Figures in 1996 CPI-U-X1 adjusted dollars.
Note: Data after 1991 are not completely comparable due to changes in the educational attainment questions.

Figure E

Entry-Level Wages for High School Graduates

college graduates in computer and engineering programs, they will move their operations abroad or import talent from overseas.

The shortage of skilled workers exacerbates another troubling trend: wage gaps among American workers. Even though the U.S. economy has expanded at a healthy clip and unemployment has dropped to new lows, the gulf continues to widen between the salaried employee with a relatively higher education and the hourly worker with limited schooling and skills. Only those equipped with at least a college degree have seen their real family incomes increase over the past two decades, while those with less education have suffered income losses.[4] *(See Figure D.)* A major cause of this widening income gap is the long-term slump in job earnings for much of working America.[5] Hardest hit are unskilled workers, whose real hourly wages have eroded the most. *(See Figure E.)*

The skills and income divides are not new.[6] Across the country, there are many, often dueling, perspectives on the major causes of income inequality. Some analysts argue that international commerce is pitting U.S. workers against laborers from low-wage countries. The expansion of global trade, they say, leads to a polarization of wages between the skilled and unskilled. But others point out that most Americans work in industries unaffected by trade, making it difficult to conclude that international competition is the sole determinant of U.S. wages.[7]

Indeed there are a host of contributing factors, including technological change, immigration, the productivity slowdown, weaker unions, deregulation, the growth of the service sector, and the dilution of the minimum wage.[8] Of these, technology is getting much of the attention.

New information technologies skew

Source: Fig. D: Bureau of the Census, March Current Population Survey.
Fig. E: Economic Policy Institute analysis of U.S. Bureau of the Census Current Population Survey data.

the earnings distribution by placing a premium on skilled labor and by reducing the demand for, and wages of, the lesser skilled. This is not only the prevailing viewpoint of private sector economists;[9] the concept has gained momentum among U.S. policymakers. U.S. Deputy Treasury Secretary Lawrence Summers, for example, points to fast-paced technological change and the highly cultivated information society as "far more responsible for changes in the wage structure in this country than is international trade."[10]

Whatever the precise mix of variables may be, one fact is inescapable: skills make or break worker employability and business productivity. And they will take on even greater importance as the United States moves toward a knowledge-driven economy.

...skills make or break worker employability and business productivity.

What Is Propelling the Race for Skills?

Technological Strides. The advance of information technology over the past 20 years has greatly expanded the demand for skilled workers and diminished the demand for the unskilled. The pace of technological change is powered, in part, by workers who can learn quickly and apply new skills. And even in the best circumstances, technology advancements often push the expectation for higher productivity cycles beyond the capacity of the American workforce because employees are not adequately trained to meet ever increasing demands. Those who fail to absorb new skills are left behind or lose their jobs to foreign competition.

The speed of change has created a new definition of worker responsibility. With hierarchies flattening and accountability pushing down to the ranks, employees are much more involved in many, if not all, aspects of their businesses. It is up to workers to continuously update their skills, and that makes learning a full-time proposition. Life is no longer segmented into hours or years allocated for school and work. Those distinctions are now blurred — schooling continues in the workplace, and beyond.

To accommodate this, schools and corporations are increasingly pressed to shorten and sharpen the learning cycle. Indeed, this development is both part and product of rapid technological change. More and more, the time needed to earn a degree is one year vs. two, two years vs. four. Training sessions are truncated to help individuals move quickly into jobs. No one can afford to wait, now that individual economic security depends on employability instead of job or career stability.

Global Competition. The rapid growth of global competition means that now, more than ever, workers need the education and training to produce value-added goods and services that domestic and overseas consumers want to buy. Government statistics show exports generated roughly one-third of all U.S. economic growth during the past decade, and export-related jobs pay 15 percent more than the average wage. The trend toward export-generated economic growth is obvious, but it can only be ensured with an increasingly skilled workforce.

There is another very compelling reason to boost the skills of American workers. The global economy puts the low-skilled and unskilled at a competitive disadvantage by depressing their pay, at best, or by eliminating job opportunities altogether. American workers are competing against their counterparts in rapidly growing emerging markets where labor is available at a fraction of the cost in the United States The higher the skills, the better the prospects for American competitiveness. Without them, many Americans will spin their wheels, working multiple jobs and logging longer hours, with little mobility or income gains to show for their efforts.

Lost Ground to Make Up. Too many people trying to enter the workforce fall far short of the most minimal criteria. While this is not a K–12 study, it is important to repeat a constant refrain heard in interviews and site visits nationwide: secondary schools are failing to turn out enough people ready to work and learn. Education not only boosts productivity in the workplace; it can also help close the gap between the skilled and the unskilled as more workers are able to perform sophisticated jobs.

Global comparisons show how poorly prepared our youth are for the world of work. In the U.S. Department of Education's most recent international study, U.S. eighth graders placed an embarrassing 28ᵗʰ in the world in math and 18ᵗʰ in science.[11] Fewer than half of U.S. high school graduates complete Algebra II or Chemistry, prerequisites for college math and science.[12] Despite the dynamism of the economy, troubling numbers of new entrants are unprepared for work. Several months after commencement exercises, the unemployment rate for 1996 high school graduates was 24.4 percent.[13]

Workforce Changes. The United States has an aging workforce and a youth population that is largely unprepared, creating a polarization that threatens the survival, much less the competitive edge, of U.S. firms. The U.S. Bureau of Labor Statistics (BLS) estimates that by 2005, the number of workers 55–64 years old will jump 50 percent from 1995 levels. Companies are seeing vast portions of their skilled workforce retire, and they are scrambling to fill the void.

In the coming years, new entrants to the workforce will present an even tougher challenge: they are projected to be the least prepared and the most ethnically, racially, and gender diverse in history.

[illegible] U.S. Census Bureau

While in the 1950s most immigrants came from European countries, today more than half of the roughly 800,000 legal immigrants who enter the country each year come from seven developing countries: Mexico, the Philippines, Vietnam, the Dominican Republic, mainland China and Taiwan, Korea, and India. The majority of today's immigrants are far less skilled than the majority of U.S. born workers. Male natives are two and a half times as likely to have finished high school as immigrants are.[14] This is a strong signal that basic skills education is critical to placing incoming immigrants in work that is both productive and a means toward self-sufficiency.

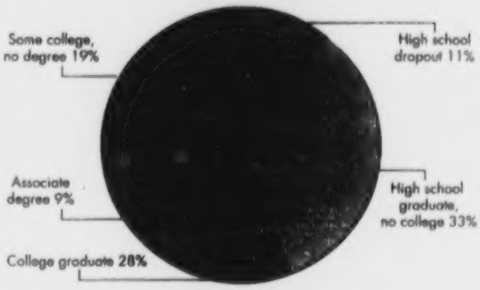
Across the labor pool, the skills shortage is no longer an imbalance. It's an urgency.

A Race We Must Win

The stakes are high for the U.S. economy. More than eight years of record economic expansion have failed to significantly boost incomes among middle Americans, reduce the levels of poverty, or afford low-skilled workers higher living standards. A drop-off in economic growth can only hurt the outlook. If we ignore the skills shortage:

...the income gap will widen further. The vast majority of American families have experienced either modest income growth or an actual erosion in their living standards in recent years, while the small minority of upper-income families had income growth.[15] While families certainly move between income quintiles, it is disturbing that, between 1989 and 1996, the lowest quintile of families saw their incomes decline eight percent, while the top quintile's grew five percent.*(See Figure F.)*

Figure G
Educational Attainment of Civilian Labor Force 1996 (Age 25 years and older)



...the cycle of poverty will not be broken. The widening of the income distribution contributes directly to child poverty because the sharpest loss in real incomes has been to young people just beginning their working lives.[16] More than a third of all America's poor children belong to families in which at least one parent works all year, but whose earnings can't lift the family above the poverty level.[17] The connection between education and earnings is unmistakable: forty percent of parents in working poor families are high school dropouts. Another 35 percent have no education or specialized training beyond high school.[18]

...U.S. workers with limited education and training will be left behind. Although the economy is improving, the living standards of many working families are not. Over the past 20 years (1975–1995), the earnings of high school dropouts did not even keep up with inflation, and high school graduates barely kept pace. While it is troubling that little more than a fourth of the entire civilian labor force has a college degree, it is striking that this portion of the workforce is the only one that has been able to keep up

Source: Fig G: Bureau of Labor Statistics

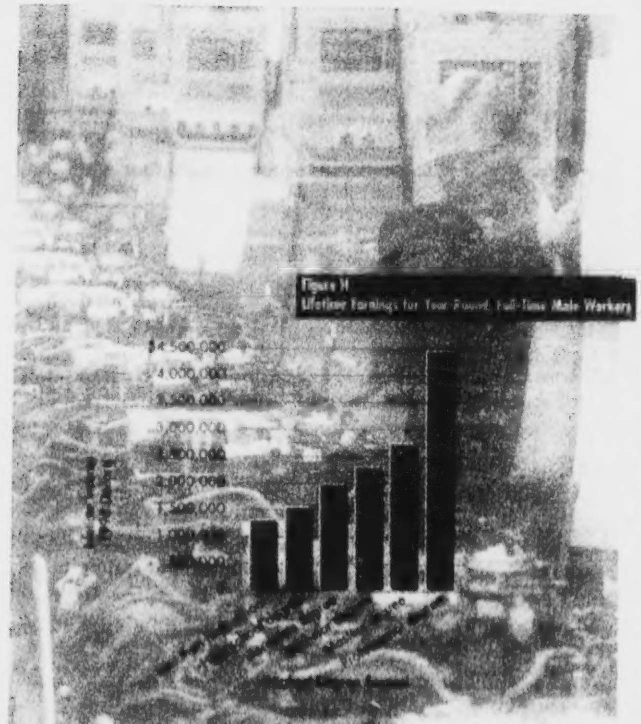


Figure H
Lifetime Earnings for Year-Round, Full-Time Male Workers

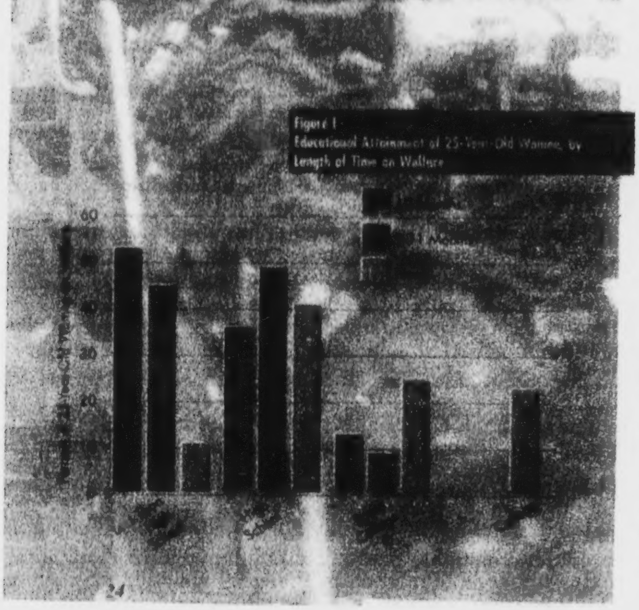


Figure I
Educational Attainment of 25-Year-Old Women, by Length of Time on Welfare

with inflation.[19] If these patterns continue, lifetime earnings differences between high and low levels of education will become even more dramatic. *(See Figures G and H.)*

…competition for low-skilled jobs will increase, especially as welfare recipients move off the rolls. The 1996 welfare reform bill has already begun to move waves of chronically unemployed heads of dependent households off of public assistance. A robust economy has helped reduce the number of welfare families by almost one-quarter since January 1995, to a current level below four million. But these people were the easiest to place in the workforce, because they typically have some secondary education and work experience. And there is no guarantee that even a minority of this group will actually stay employed. The biggest obstacle lies ahead as recipients with marginal educations and no work experience are shifted off the rolls. Even under the best conditions, the current glut of low-skilled workers — which has already reached a startling 15 applicants per open position in some Midwestern urban areas — will increase.[20] Without the proper education and training, they will have nowhere else to turn. ***(See Figure I.)***

America cannot afford to lose the skills race. We will *all* fall short of the hurdles unless we work together toward a comprehensive education and training strategy. Encouragingly, the key players — business leaders, workers, educators, and government agencies — see that they can best accomplish their common goals as a team. The winning examples cited throughout this report demonstrate that these problems are not insoluble. They are models for what can be championed through collaboration.

Source: Fig. H: Based on US Census Bureau income data calculated over the years of 18 to 64.
Fig. I: Burtless, Gary. "The Employment Prospects of Welfare Recipients." *The Work Alternative: Welfare Reform and the Realities of the Job Market.* Demetra Nightingale and Robert Haveman, Eds. Washington, DC: Urban Institute Press, 1995.

End Notes:

1 Nickell, S. and Bell, B. "Changes in the Distribution of Wages and Unemployment in OECD Countries." *American Economic Review.* May 1996, pp. 302–308. Uses data from the 1995 OECD Literacy Survey.

2 The Hudson Institute and U.S. Department of Labor.

3 Behr, Peter. "Cultivating a New Crop of Workers: Training and Nurturing Replace Bidding Wars." *The Washington Post.* December 1, 1997, p. A1.

4 Statistics like real median household income and real earnings are affected by the consumer price index (CPI). The Boskin Commission estimated that the current CPI overstates inflation by 1.1 percentage points per year. Although removing CPI bias would change some of the details of productivity and income trends, it would not alter our views of an increase in income inequality over the past two decades or the fact that real wages are growing more slowly than in the 1950s or 1960s. Source: U.S. Department of Labor. *Economic Report of the President.* February 1997, p. 71.

5 Wages make up roughly three-quarters of total family income with the remaining quarter made up of capital income, such as rent, dividends, interest payments, and capital gains.

6 For more than a decade, concern has been growing about the relationship between competitiveness and the inadequate skills of American workers. In 1983, in "A Nation at Risk," the National Commission on Excellence in Education chillingly concluded that a "rising tide of mediocrity threatens our very future as a nation and a people." That was followed by the Hudson Institute's "Workforce 2000" (published in 1987), which stressed the long-term implications of a growing skills shortage in the United States. In June 1990, The Report of The Commission on the Skills of American Workforce "America's Choice: High Skills or Low Wages!" was released, warning that the country was, without realizing it, choosing a road to low-wage jobs. The only solution was to upgrade our education and training systems. Finally, the Secretary's Commission on Achieving Necessary Skills (SCANS) published its initial report, "What Work Requires of Schools" in 1991, which concluded that schools were not teaching students the basic skills needed to succeed in the workplace. The Commission recommended that the nation's school systems make SCANS foundation skills and workplace competencies explicit objectives of instruction. These four reports have made headlines around the nation and raised concerns that the supply of skills in the U.S. economy has not kept place with the growing demand.

7 Burtless, Gary. "Worsening American Income Inequality: Is World Trade to Blame?" *The Brookings Review.* Spring 1996, pp. 27–31.

8 Richard Freeman is among the many economists who have tried to analyze why the U.S. is experiencing growing income inequality. Source: Freeman, Richard B. *When Earnings Diverge: Causes, Consequences, and Cures for the New Inequality in the U.S.* Washington, DC: National Policy Association, 1997.

9 Robert Lawrence of Havard's John F. Kennedy School of Government and Paul Krugman at the Massachusetts Institute of Technology are the leading advocates of this position.

10 Shepherd, Bill. "Defusing Globalization: A View From Washington." *Global Finance.* November 1997, p. 38.

11 U.S. Department of Education, Office of Educational Research and Improvement. Third International Mathematics and Science Study (TIMSS), 1997.

12 National Research Council. Cited in Information Technology Association of America's *Help Wanted: The IT Workforce Gap at the Dawn of a New Century.* Arlington, VA, 1997.

13 U.S. Department of Labor, Bureau of Labor Statistics. "College Enrollment and Work Activity of 1996 High School Graduates." July 1997. Information from the Current Population Survey.

14 Cassidy, John. "The Melting Pot Myth." *The New Yorker.* July 14, 1997, p. 41.

15 There are a lot of government data and policy groups that make this point. This was drawn from Mishel, Bernstein, and Schmitt. *The State of Working America 1997.* Economic Policy Institute, p. 50.

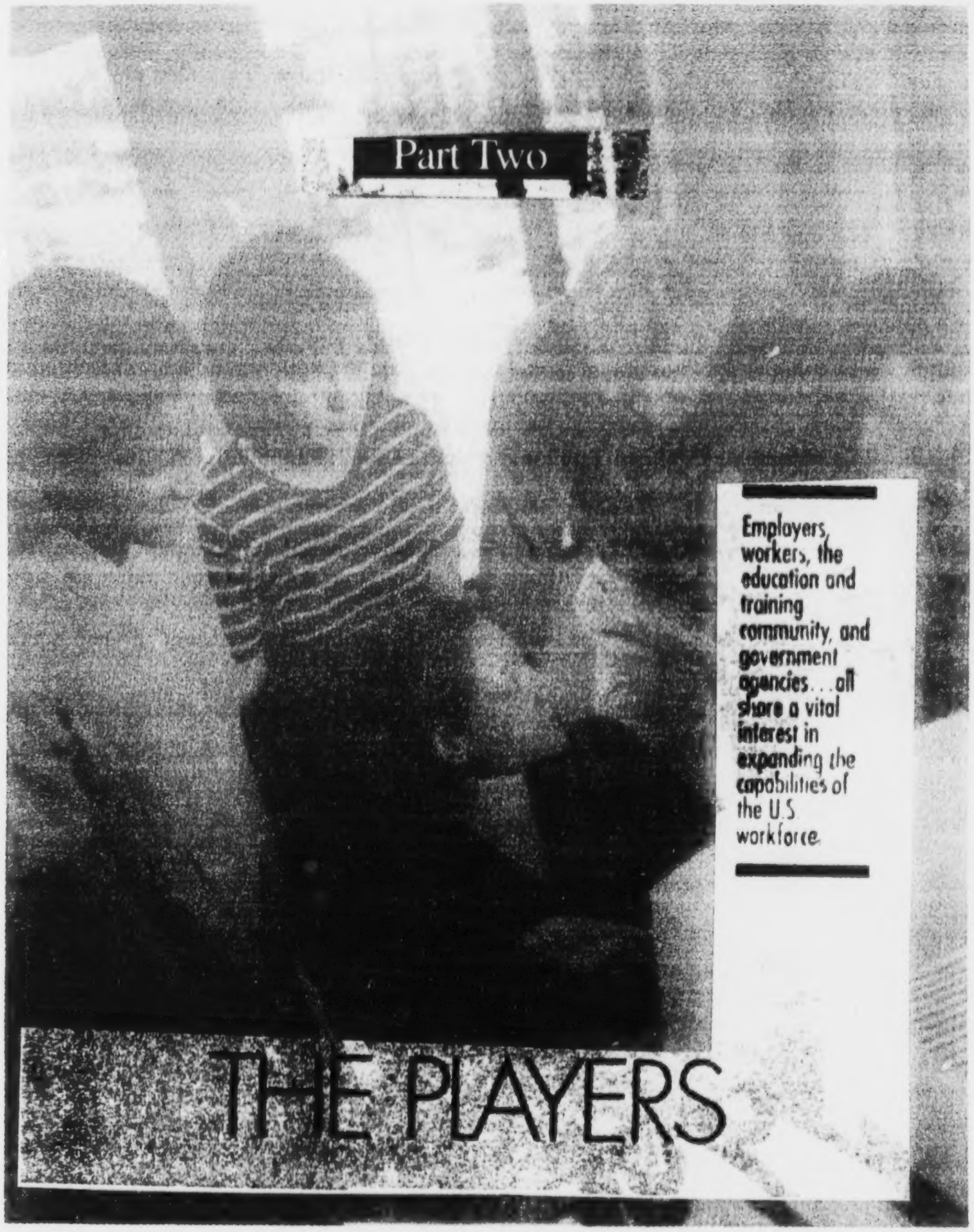
16 Freeman, Richard B. *When Earnings Diverge: Causes, Consequences, and Cures for the New Inequality in the U.S.* Washington, DC: National Policy Association. 1997, p. 46.

17 U.S. Bureau of the Census, March 1994 Current Population Survey data. Cited in: Annie E. Casey Foundation,*Kids Count Data Book.* 1996, p. 5.

18 Annie E. Casey Foundation, *Kids Count Data Book.* 1996, p. 7.

19 U.S. Bureau of the Census, Current Population Survey data.

20 Cited in *The Wall Street Journal.* July 29, 1997, p. A1.



Part Two

THE PLAYERS

Employers, workers, the education and training community, and government agencies . . . all share a vital interest in expanding the capabilities of the U.S. workforce.

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THE PLAYERS

Employers, workers, the education and training community, and government agencies are the four major stakeholders in workforce preparation. All share a vital interest in expanding the capabilities of the U.S. workforce: **Employers** seek increased productivity to strengthen the bottom line. This goal requires a workforce that can adapt quickly to new tasks and to new market demands. **Workers** seek higher wages and job market security, which they can attain only by investing in their own skills. **Educators and trainers** face rising expectations from students, workers, employers, and communities to meet the increased demand to develop skills. Their future depends on being able to successfully place graduates into the market. **Federal, state, and local government agencies** see that their efforts in workforce development programs must be more focused and more localized to generate economic growth.

This chapter outlines the interests of the stakeholders and shows why they cannot run alone.

Part Two

AMES RUBBER CORPORATION

Ames Rubber Corporation is acutely aware that the mismatch between workers and jobs hurts the firm's ability to grow and prosper. Located in a rural, farming community in northern New Jersey, Ames Rubber is particularly limited by the area's low unemployment levels and geographic isolation. Charles Roberts, vice president of total quality, identifies many of the problems and prospects:

"It's almost impossible to find skilled labor. Even though our requirements are minimal (workers with basic verbal skills who are able to do calculations and perform math at an eighth-grade level), we are compelled to put a lot of time and resources into remedial efforts because our recruiting options are so poor. Job applicants are told up-front that they will be tested for basic competencies and that those without basic skills will need to bring themselves up to speed if they expect raises and promotions within the company.

We feel we're giving workers a second chance by helping them improve their basic literacy skills, but it's a difficult undertaking for many. Although we are committed to not laying off workers due to quality improvements, those workers who refuse to upgrade their skills face a dim future — not only for this job, but down the road when workplaces demand even more sophisticated skill sets. Employability is key to job security. And to stay employable, workers must be willing and able to learn throughout their lifetimes. For those who maintain and improve their skills, the changes should bring increasing rewards. For those who fall behind the curve, the way out is more costly, and more remote.

We realize that remedial education is a short-term, band-aid solution and that real change has to happen through K–12 reform. The schools are not graduating students with the necessary skills. We need to be better about articulating our skill needs, disseminating them to the schools, and assisting in redesigning curricula.

School-to-work that marries meaningful work-based learning experiences with challenging academics is considered by many to be a best practice, although it has not yet been brought to scale anywhere in the United States. Partnerships between business, schools, and other community players can help improve learning and can give students an early glimpse at what competencies are needed to excel in the world of work."

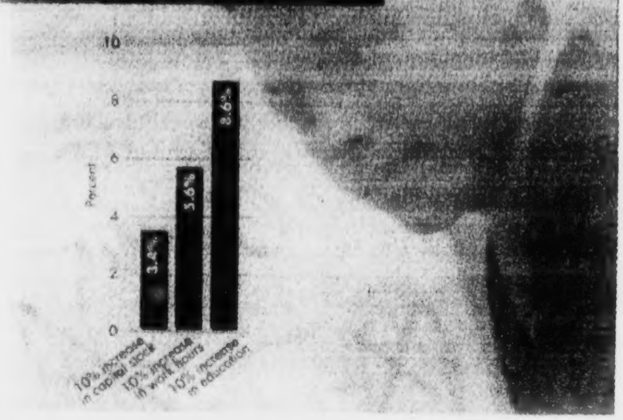
Companies like **Ames Rubber** are overwhelmed by how multidimensional their training needs are. They not only have a baseline requirement for workers who can read and do simple math, but also are calling on increasing numbers of employees to communicate well, use technology, solve problems, think critically, and understand the larger business context.

The training agenda for business starts with basic skills and workplace fundamentals. Entry-level workers unfamiliar with the work environment must learn how to meet even the simplest requirements to show up on time and notify superiors of absences. Yet many workers (even those with high school diplomas) lack basic competencies in reading, writing, math, and computers. Unless **Eastman Kodak Company** employees have a solid understanding of basic math, for example, they cannot comprehend how to build or use formulas on an Excel spreadsheet. For companies like Kodak that have spent millions of dollars on statistical process control systems, poor math preparation is a major stumbling block that often hinders their ability to quickly roll out sophisticated operational conversions.

Beyond the fundamentals, pressure is mounting to continuously upgrade the skills of incumbent workers. More than ever, employed workers are participating in skill improvement training for their current jobs.[1] Rapid workplace changes mean workers' knowledge has to be continuously updated. More than half of companies surveyed in a Bureau of Labor Statistics (BLS) study provided training to upgrade or reorient worker skills in response to changes in technology, production methods, or both.[2] This level of continuous learning isn't surprising to firms like **Hewlett-Packard,** where new products and services are being introduced every year, placing new demands on all employees — from the factory floor to senior management.

Training requirements are ratcheted up in the knowledge-based economy, and they now outpace the capacity of firms to respond. Although employers spent an estimated $55.3 billion in 1995 on formal training for the civilian workforce, employer-provided training does not appear to have kept pace with the increase in the number of workers over the past 15 years.[3] Training expenditures per worker appear to have fallen,[4] despite the fact that training pays off. Employers achieve an 8.6 percent improvement in productivity for every year of worker education.[5] *(See Figure AA.)* For that same year, employees who receive training enjoy wages as much as 16 percent higher than comparable workers who do not receive training (even after controlling for education levels and a variety of

Figure AA
Additional Education Boosts Productivity More Than Other Inputs



Source: Fig. AA: National Center on the Educational Quality of the Workforce, "The Other Shoe: Education's Contribution to the Productivity of Establishments," 1995.

Figure BB
Growth of Corporate Universities

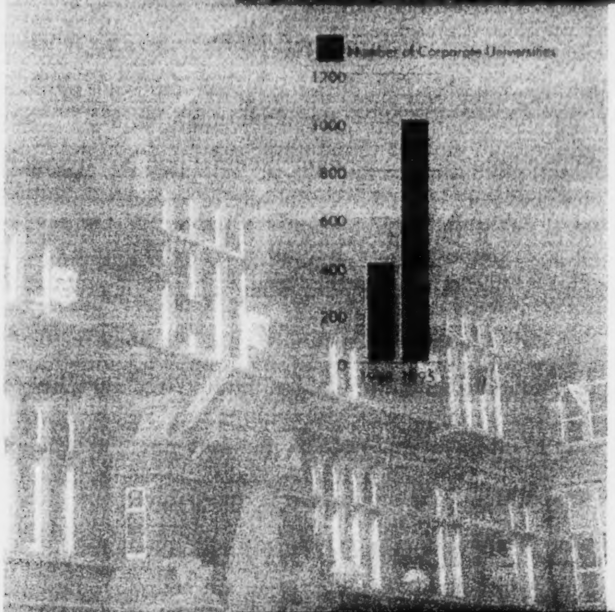
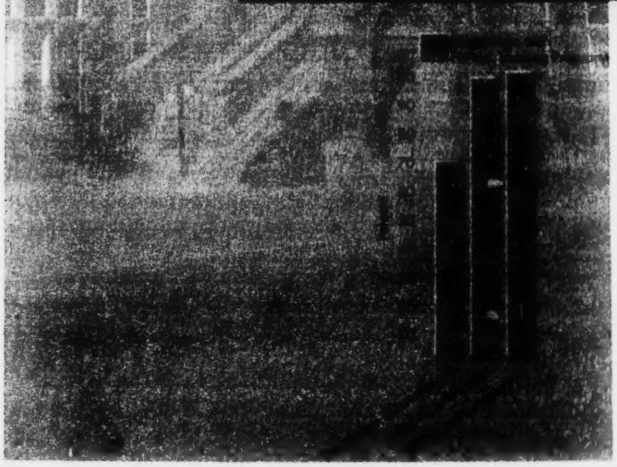


Figure CC
Firms With Formal Training Programs by Establishment Size



other factors that affect earnings).[6]

The response of U.S. firms to rising demands for training is, at best, uneven. Only a small fraction of private industry invests in preparing its *overall* workforce. Indeed, workplace training tends to favor the advantaged; although those with college degrees represent only 25 percent of the workforce, they received 38 percent of the training in 1991. Conversely, those with a high school education or less got 38 percent of the training but represent 53 percent of the workforce.[7]

The 70 percent of employers that *do* conduct formal training assign particular priority to what feeds into the bottom line of company operations. While companies routinely invest in computer training, for example, a very small percentage of all establishments offer formal training in basic reading, writing, arithmetic, and English language skills.[8] Yet, in surveys done by the Olsten Corporation, almost half of employers reported that their workers needed to enhance their reading or math skills in 1994 — twice as many who reported so just three years earlier.[9] Data like this are common and point to basic skills training needs that far exceed employers' efforts to provide such training.

Some of the biggest companies are demonstrating their commitment to learning by creating education/training units within the corporate structure. These "corporate universities" have grown from 400 in 1988 to more than 1,000 in 1995 (now estimated at 1,200 to 1,500).[10] *(See Figure BB.)* But a significant portion of these training expenditures are by large manufacturing firms and directed to professional and managerial staff, not front-line workers.

Large firms like **Xerox Corporation**, which invests substantial sums in training its workforce, are exploring more decen-

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Source: Fig. BB: Quality Dynamics Inc. 1996 Survey of Corporate University Future Directions.
Fig. CC: Bureau of Labor Statistics, 1993 Survey of Employer-Provided Training.

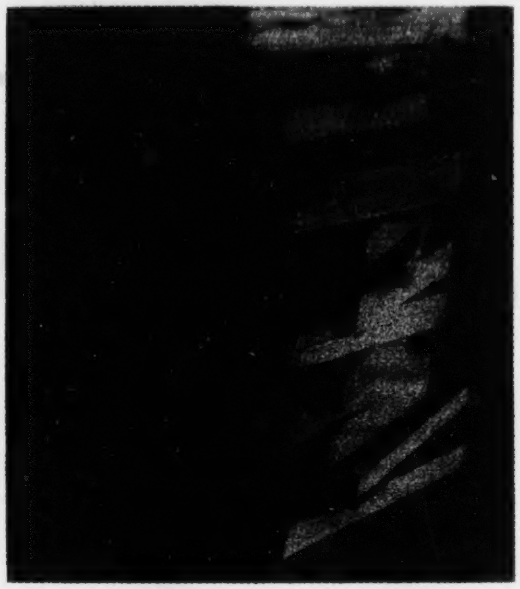
tralized strategies that allow employees to pursue the training and educational opportunities they deem appropriate. Managers within each business division identify learning opportunities for employees, based on their selected career paths. As corporate training departments shrink,[11] firms are relying on such decentralized strategies to ensure that the workforce continues to improve its skills and that employees have the learning opportunities they need to move up the ranks. This trend puts added pressure on each division of large companies to make smart, cost-effective investments.

Small and mid-sized companies are major job generators in the U.S. economy, yet their workers operate at a distinct disadvantage. The BLS studies show that smaller firms are far less likely than their larger corporate counterparts to train their workers. Small firms spend approximately one-third as much per employee on formal training as do large employers.[12] Yet, small business training needs are critical. These firms not only provide the first work experience for two out of three workers, they are also important providers/suppliers to larger companies that rely on services/goods of smaller firms to beat global competition.

Many small firms are severely limited by a lack of personnel, funding, and the benefit of economies of scale. As *Figure CC* shows, almost all private sector establishments with 50 or more employees provided some formal training programs for workers. But just 69 percent of employers with fewer than 50 employees provided any formal training.[13] And, according to the Small Business Administration, less than one-fifth of firms with fewer than 25 employees have comprehensive training programs.[14]

Smaller firms have trouble rationalizing the costs of formal training, which can include employee testing and assessment, employee development plans, and performance-based evaluation systems. All of this means time away from the job and lost productivity, for both the trainer and trainee. And because worker training can be expensive, small firms in particular fear that their employees will take their new skills and knowledge and go elsewhere for employment. This issue came up repeatedly during our own focus group discussions, although studies have shown that participation in employer-provided training actually reduces the likelihood of an employee leaving the employer.[15] And given the job churning in today's market, small firms are particularly sensitive to the costs of locating and training replacement workers — costs that can quickly become prohibitive.

New training requirements have left all firms in a state of flux. Employers are struggling to determine where to allocate resources, which training tools to use, and how to maximize their impact.



INLAND STEEL FLAT PRODUCTS COMPANY

As a member of United Steelworkers of America Local 1010, Nick Nash and other hourly workers at Inland Steel Flat Products Company in East Chicago, Indiana, are the beneficiaries of a labor-management contract that sponsors on-site classes through the JobLink 2000 center. Nick has taken advantage of the opportunity to take courses relating to personal development, retirement, or future academic needs, at no cost. JobLink, he says, has opened new doors for him:

"I first took a class in Residential Wiring in 1994. I was doing some work on my home and wanted to pick up the skills needed to rewire my garage. I enjoyed it so much I enrolled in Carpentry I and II and Advanced Carpentry I and II. I then had the skills to build a deck around my house. Knowing how to do it by myself saved me a lot of money, and it was very rewarding to complete such a major project.

I continued with other home-improvement classes, each lasting about four months, but then I also began branching into computer courses. JobLink offers courses ranging from the basics like keyboarding, word processing, and using the Internet to sophisticated desktop publishing and spreadsheets. And most recently, I took flying lessons with the money available through the Tuition Assistance Program offered by Inland.

The experiences have really helped me think about what I'll do after I leave Inland. Jobs are no longer secure in this industry, and there's always retirement. I think I want to build a log cabin for myself, possibly in New Mexico. And in the meantime, I have improved my reading abilities, sharpened by math skills, and gained a lot of confidence about being a 'student' again. I plan to keep taking classes as long as I can."

Why Workers/Unions Can't Run Alone

Workers, like Nick Nash, ever less secure about their positions and prospects, are increasingly aware of the need to boost their skills and marketability. But often, they lack the perspective and opportunity to realize that goal.

Overall, U.S. workers get roughly the same share of job-related training as in other major countries. *(See Figure DD.)* But formal training is biased toward the haves. It typically favors: the college educated; men, who have both a longer history in the workforce and who pose little threat of leaving work for child rearing; whites over blacks and other minorities; and workers between the ages of 35 and 44 — a group that has logged enough time on the job to be valuable and not too much time to soon be considered obsolete.[16]

Unionized workers, making up roughly 10 percent of the industrial workforce, are more likely to receive formal company-provided training than nonunionized workers.[17] For workers looking to transition into new jobs within the same company, those in unionized firms often benefit from job training programs that are a product of labor-management collaboration. Collective bargaining objectives have shifted from *job security*, or keeping one's present position, to *employment security*, which ensures workers opportunities in the broader job market. Labor and management work together to provide opportunities for union members who receive training and education to improve existing skills or to learn new skills for greater employability.

For example, through the collective bargaining process, **Inland Steel** has committed to training 10 percent of its unionized workforce at any particular time. These worker education programs have proven so effective that the number is more like 25 percent according to workers and managers. To increase job opportunities within the firm, the steel producer instituted something called "criterion referenced instruction" — a complex system that clearly identifies the skills and knowledge needed to successfully perform 400 jobs in the plant. Because of the constant introduction of new equipment and new processes, labor and management wanted to devise a system that clearly laid out job qualifications, encouraging workers to upgrade their skills and making it easier to obtain new positions within Inland.

Beyond training in the workplace, some firms underwrite the schooling costs for workers. By 1995, 65 percent of employees at medium and large firms were eligible for job-related tuition benefits, and 18 percent could get financial help for courses not related to their jobs.[18] And workers are taking advantage. Nearly half of the 14.2 million college and university students in the United States are over 24 years old, and that percentage of

Source: Fig. DD: Organization for Economic Cooperation and Development, Education at a Glance: OECD Indicators, Indicator F8, 1995.

older students — most of them coming back to school after years in the workforce — is still rising.[10] The 1998 tax law recognizes this trend and offers several different kinds of credits that can be used to help offset college costs.

But those workers who, on their own, choose to pursue education and training through outside sources, are by no means guaranteed that their investments will pay off in higher wages or career opportunities. While work-based training increases individual earnings, the benefits are not as clear when individuals go it alone

Even the most reputable education and training programs do not always ensure that their programs are tailored to business needs. In too many instances, workers have no way of knowing if the courses they are taking, often on an ad hoc basis, are tooling them with the "right" skills. And although the training may be valuable, most individuals do not receive portable credentials or certification unless they pursue full degrees.

For would-be new entrants and incumbent workers, the problem is two-pronged. First, individuals themselves are not taking the initiative, often because they lack good information about what skills they need, how they can be acquired, and where they can be applied. Second, for those with the motivation, learning opportunities are often severely limited by time, expense, and lack of availability. As learning becomes a lifelong need, no worker will reach his or her potential without ready access to quality skills training.

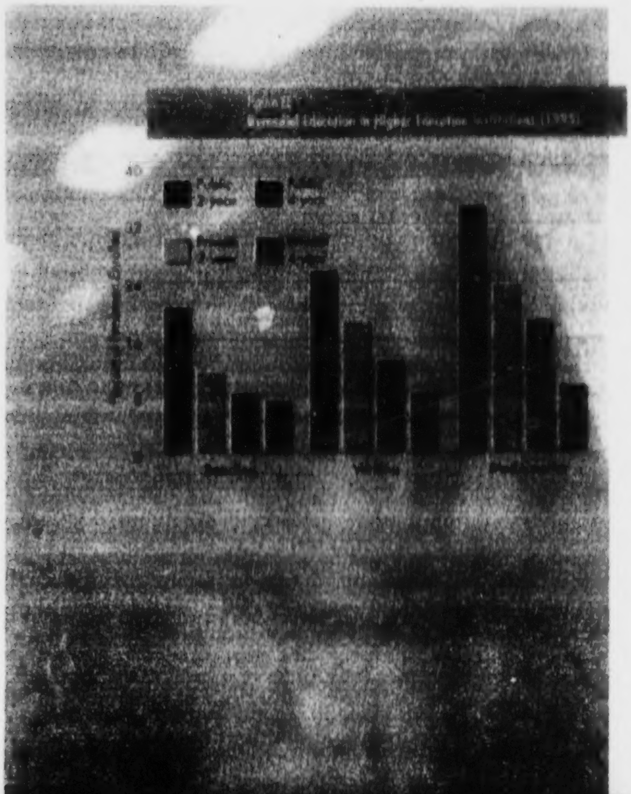
VALENCIA COMMUNITY COLLEGE

Valencia Community College in central Florida has been ahead of the national pack in designing education/vocational programs that connect its participants directly to the job market. Susan Kelley, Valencia's vice president of resource development and governmental relations, has worked closely with government agencies and private firms to rationalize the costs associated with workforce preparedness. She's intent on showing results:

"That's what community colleges can do and should do; it's why industry pays taxes. Valencia is an active partner in local economic development. We anticipate opportunities for economic expansion and work directly with businesses to maximize those opportunities. Everyone wins, and the region's economy is boosted.

I was an early supporter of performance-based funding and budgeting for public educational institutions in Florida. Colleges now must risk 20 percent of their funding and prove to the state that they can successfully place graduates in promising fields identified by the state's occupational forecasts. This element of competition keeps everyone sharper. We regularly track job placements and survey employers on their skill needs, and it's paying off — Valencia has earned back more than its 20 percent every year.

We partner with all Central Florida businesses, from entertainment and hospitality to health care and the film industry. Our students must be trained so they leave ready to work in a good paying job. . . a job that exists. This is especially critical with the effects of welfare reform. An estimated 45,000 welfare recipients will try to leave the Central Florida's rolls over the next two years. We have to ensure that our education and training programs are designed to meet the needs of the long-term unemployed and satisfy job requirements."



Remedial Education in Higher Education Institutions (1995)

Why Educators and Trainers Can't Run Alone

Educators like Susan Kelley recognize that the success of schools is very much dependent on the economic success of the communities in which they reside. No matter what level of post-secondary institution — from the research universities to community colleges — the value of all education and training providers is measured by their direct contribution to economic development.

A particular challenge for post-secondary schools is the number of students who leave high school unprepared for higher learning. In most medium-sized to large four-year colleges, at least one-fourth of the freshmen require remedial education in mathematics and reading before they can do college-level work.[20] And two-fifths of freshmen in public two-year colleges register for remedial courses. As *Figure EE* shows, America's well-regarded system of higher education is devoting too many resources to *re-do* what should have been done already.

Meanwhile, schools are enrolling more and more older students, who are motivated by increasing educational requirements for employment, changing life circumstances, and personal growth. Currently, more than 50 percent of higher education students work — and their goals are to upgrade, retrain, or advance.[21] Because four-year universities, in general, have not emphasized learning for work, students looking for practical educational avenues into the workplace often turn to community colleges.

Education for work has long been a key component of the community college mandate. These institutions are within commuting distance for most of the population; they are community-centered and often have ties to business and industry;

Source: Fig. EE: U.S. Department of Education, National Center for Education Statistics, Remedial Education at Higher Education Institutions in Fall 1995.
Fig. FF: Developing the World's Best Workforce: An Agenda for America's Community Colleges. Community College Press, 1997.

they are relatively inexpensive; and their open enrollment policies make them accessible to all. *(See Figure FF.)*

But as the hubs of continuous learning, community colleges are being pressured to do more than just provide flexible, cost-effective courses. The pressures are from students and employers — those who receive the training and those who finance it — who demand a clear return on their investment.

Successful community colleges are increasingly customer conscious and responsive to firms large and small. **Valencia Community College's Office of Corporate Services** actively seeks out Orlando-based firms that would benefit from on-site needs assessments and evaluations, training and education, customized course development, and continuing professional education courses. With less than four percent unemployment, local businesses are clamoring for the school's help in educating both entry-level and incumbent workers. And the school's client base (which has grown ten-fold since 1992) not only expands its reach in the community, it reaps additional revenue.

If community colleges do not measure up, firms can turn to alternate sources. Many newcomers in the education and training field are cashing in on a skyrocketing demand for their services. Some of the stiffest competitors are private providers responding to the wave of firms outsourcing many of their training functions. The combined sales of **Knowledge Universe**, a Los Angeles-based holding company of training and consulting firms, were forecast to reach $1 billion by 1998. According to one estimate, the market for information technology education and training services alone was $4.4 billion in 1996 and is expected to grow to $7.4 billion in 2001.[22] The American Society for Training & Development (ASTD) recently found that the market value of firms providing customized training has appreciated at more than twice the rate of Standard & Poor's 400 Industrials over the past two years.[23]

Post-secondary education, whether publicly or privately funded, will have to meet the rising demands of workers and employers for marketable skills, as well as the expectations of community leaders for economic development.

WASHINGTON STATE'S WORKFORCE TRAINING AND EDUCATION COORDINATING BOARD

Washington State's Workforce Training and Education Coordinating Board, which advises the governor and legislature on workforce development policy, deals directly with Washington's employers and workers. Only after identifying the major gaps in the supply and demand for training can the Board strategize how to best serve its customers. Board Chair Betty Jane Narver explains:

"Education and training are critical to the economic growth of Washington. If employers cannot find trained workers locally, they will look to other states or nations, or they will have to design new jobs that do not require high skills or pay high wages. The state has to coordinate its economic development and workforce training programs to encourage the growth of high-performance firms where workers participate in decisions, work in cross-functional teams, and manage their own career development.

Shortages are particularly critical in occupations that require technical training beyond the high school level. A recent survey found that 81 percent of employers who tried to hire workers with a vocational degree or certificate had difficulty finding qualified applicants. Each year, the state produces less than 21,000 graduates with two years of post-secondary vocational training, although there are about 28,000 job openings per year. And many businesses expect their need for such workers to increase over the next five years. Community and technical colleges need to market their offerings better by showing students how valuable a two-year degree is in the market. In particular, degrees in computer science and computer engineering are in high demand.

Firms are also in need of retraining services for their incumbent workforces. Although the students who attend community and technical colleges for workforce training are generally satisfied, many employers perceive a mismatch between the kinds of training they are seeking for their current workers and that offered by public providers.

It is the Board's job to ensure that the state's workforce training and education system meets these needs. And to do that, we have to give both of our customers – business and labor – a voice and the opportunity to shape education and training in their local communities."

Why Government Can't Run Alone

Washington State's intensive efforts to match education and training with market demands are emblematic of efforts in state capitals across the country to keep and attract high-wage jobs. States like Washington recognize that competition for economic development can be won or lost by the availability of trained workers. To win this battle against other states and against locations around the world, they are developing and delivering comprehensive employment services designed to serve their local populations, including labor market information, training, job counseling, and placement.

With an eye toward economic development, 47 states now offer some type of customized job training program to existing or new businesses. States have stepped up their investments in economic development, on average, by about 29 percent a year over the last 10 years (totaling $2 billion in 1994). This and other analysis by the National Alliance of Business shows that states that have a more educated workforce and that devote more state and local resources to education see improved economic performance.[24]

With an eye toward economic development, 47 states now offer some type of customized job training program to existing or new businesses.

But there are risks in the intense competition among states to keep or attract corporate investment. The AFL-CIO, for instance, takes issue with states that are too anxious to accommodate business needs and may, in effect, distort the original purpose of training dollars to attract firms. The labor organization points to the 1993 case in which Alabama enticed Mercedes to build an automobile plant within its borders by extending tax abatements that actually reduced resources for a state special education trust fund. Although a new governor stepped in with an alternative incentive for the company, the AFL-CIO and other critics still question whether such decisions are the best use of limited resources. But states argue that such investments pay off in terms of new jobs and long-term economic growth.

The federal government is a level removed from the firing line of workforce development. Federally sponsored job training programs are designed for mostly disadvantaged workers who would not receive such training from an employer or could not pay for it themselves. The annual federal investment in targeted programs, estimated at $25 billion, is geared mostly to at-risk groups such as dislocated workers, low-income individuals facing significant barriers to employment, and youths who have the potential to benefit from second-chance programs.[25]

On the whole, these targeted federal programs have received low marks for effectiveness. Critics contend that the multitude of narrowly focused programs are competing for clients and funds, while administrative overlap makes the system inefficient and difficult to navigate. In 1995, the General Accounting Office concluded that approximately 40 percent of the federal employment and training programs could not accurately identify how many people they served per year. Less than half of these programs tracked participants' success in getting jobs. Only a quarter collected data on wages earned.[26]

In response, the federal government is directing state and municipal governments to improve administration and increase access by implementing programs at the local level. The U.S. Department of Labor provides funds to assist states in developing one-stop career centers that help with recruitment, training, and hiring for both job-seekers and employers.[27] One-stop centers provide a single entry point by unifying the patchwork of fragmented employment and training programs, thereby creating a more efficient system.

In addition, the federal government is increasingly becoming an initiator and a catalyst for a series of major national programs that go beyond specific classes of workers. Two of the most promising federal initiatives, school-to-work and occupational skill standards, address workforce challenges that the private sector cannot be expected to meet on its own. Both of these initiatives (discussed in this chapter) recognize the power of devolution by providing for implementation at the local level.

Why the Players Need to Run Together

Industry, workers, educators, and government officials are not always natural partners, but they are pooling their resources and expertise to tackle issues that they cannot manage on their own. Their core shared interests are the following:

1) to improve the pipeline from K–12 to work,
2) to leverage scarce training resources, and
3) to respond to market pressures.

Improving the Pipeline from K–12 to Work

Public and private sector leaders have begun to work in partnership across the country to ease the transition from K–12 to the workplace.

Congress created a framework to promote such partnerships, the School-to-Work Opportunities Act of 1994, which provides temporary planning and implementation grants to states and local communities on a competitive basis. The rationale is that states and localities should be able to design systems that reflect their own economies and that respond to their own labor market needs. For school-to-work to be successful, businesses, labor unions, schools, parents, local officials, and community-based organizations must work together. School-to-work programs give all students academic and technical training and link learning in school with the demands of the workplace.

Early evaluations suggest that school-to-work is a success story in progress. Businesses that participate have seen their recruitment costs drop and experience less turnover among new hires.[28] And students benefit from the work experience. A recent study found that a student who went directly into the workforce after high school and worked a substantial number of hours during school (15–20 hours a week), drew significantly and substantively higher earnings.[29]

The school-to-work concept has started to catch on even without the catalyst of federal grants. Intel's lead in New Mexico, for example, is typical of many firms turning to education partners for a reliable supply of skilled workers. The hands-on science learning centers developed by company managers proved so successful that they were adopted by the New Mexico State Department of Education. Intel also introduced special manufacturing classes at the K–12 schools statewide, arranged work-site opportunities for students, and offered teacher internships. The current enrollment of more than 1,500 in the post-secondary manufacturing technology degree program developed by Intel shows that students are starting to see the opportunities.

In Milwaukee, an area that lost 60,000 high-wage manufacturing jobs in the 1980s, manufacturers have banded together to regain the community's confidence in vocational education. Parents, students, and guidance counselors had turned away from this blue-collar track because it was not considered a pathway to a high-paying career. In recent years, however, local manufacturing firms and unions have established school-to-work links and youth apprenticeship opportunities to renew interest in fast-growing occupations that do not require four-year degrees. Today Milwaukee's school-to-work program is much heralded for its efforts to teach *all* children in an applied fashion, beginning in elementary school.

A nationwide coalition of service sector firms has formed a network of

SCHOOL-TO-WORK SYSTEM

The National School-to-Work Office has identified eight core principles that are key to developing school-to-work systems.

1) School-to-work opportunities are intended for all students.
All students — including the disabled, school dropouts, and academically talented learners — benefit from challenging, contextual learning. Unfortunately, many misunderstand school-to-work and treat it as enhanced vocational education for the "non-college bound." But all students can benefit from learning that is benchmarked to high academic standards.

2) School-to-work elements are incorporated throughout the school curriculum.
Career awareness and exploration must begin as early as possible. School-to-work principles can be put into simple exercises for younger students, while high schoolers participate in sophisticated work-based learning opportunities. The system builds incrementally, preparing students for each progressive step.

3) All partners involved in implementing school-to-work must be trained and given staff development opportunities.
Teachers and career counselors need to work directly with employers to learn about particular industries and workplace practices. Staff may also require training in contextual learning, portfolio assessment, and the use of technology. Employers and unions need to learn how to develop work-based learning experiences, mentoring curricula, and skill standards.

4) School-to-work systems enable students to explore "all aspects of an industry."
Building on an area first emphasized in tech-prep programs, students receive broad exposure to issues and skills related to their career of interest, rather than learning isolated task- or job-specific skills.

5) Employers and labor unions play a key role in building school-to-work systems.
Employers and unions are equal partners with education, although their involvement may vary. Firms can offer job shadowing, sponsor teacher internships, develop skill standards, and/or offer full work-based internships. Unions often concentrate on job training and workplace health and safety issues.

6) Learning is organized around career majors, which provide a context for learning and allow for connections between school-based and work-based learning.
Career majors help students learn how their strengths and career goals match with a variety of occupations. The application of lessons at an early age is key to steering students toward post-secondary and employment options.

7) States identify a "roll-out strategy" to local partnerships.
Because system-building is a long-term activity, states must have plans for spreading school-to-work to every community. Local partnerships are usually required to demonstrate through a competitive process that they are ready to implement school-to-work.

8) All partners are responsible for ensuring that their systems yield results, which are measurable and drive continuous improvement efforts.
Successful school-to-work systems can document improvement of academic performance, students' development of job skills, high level of involvement by employers and schools, and favorable labor market experience of graduates. For school-to-work to establish itself as a self-sustaining, national movement, grantees will have to demonstrate their success in qualitative measures like these.

"academies" within high schools that prepare students, many of whom are considered "high risk" for dropping out, for careers in the financial services and travel and tourism industries. This **National Academy Foundation** (NAF) has a strong track record in exposing students to job and career opportunities through student internships. For the students, the work experience reinforces the importance of schooling and gives them new incentives to graduate. For businesses, soon-to-be new entrants who work in their industries help the employers build pools of qualified workers. Virtually all students involved in NAF programs graduate from high school, and more than 90 percent go on to college.

Employers see school-to-work as a way to motivate students to perform in high school and to secure for themselves a pipeline of graduates whose skills meet their needs.

Employers see school-to-work as a way to secure for themselves a pipeline of graduates whose skills meet their needs.

Leveraging Scarce Training Resources

The magnitude of the training challenge has prompted many firms to form alliances with other firms and organizations in their communities that offer specialized expertise, information links, and economies of scale. Learning partnerships are of special value to small and medium-sized companies:

Oregon-based **Merix Corporation**, a medium-sized electronics manufacturer, has developed a network of ties with local educational institutions — two and four-year universities, technical schools, community colleges — to meet its training needs. Often, the schools are hired to develop the class material, and Merix does the training at the corporation's facilities. Merix has found these outside educational suppliers, who know Merix's business, to be especially productive partners.

Solectron, a surface mount technology manufacturer in Milpitas, California, has forged a long-term learning partnership with the nearby **Center for Employment Training** (CET) that has generated substantial benefits for both the firm and the school. The company shares its technical skills courses, donates materials, and invites teachers to shadow company employees so that the teachers can learn more about the industry and its math and science requirements. In turn, workers spend time in the classrooms as teachers' aides and student sponsors. The exchange breeds results: Solectron now regularly hires CET graduates and regards the school as a great recruiting opportunity.

The **Wisconsin Regional Training Partnership** is a local alliance of small businesses and labor organizations that work together to improve workers' skills and to support high-performance workplaces. The members of the industry consortium see its greatest values as providing opportunities to learn from their peers, improving access to public sector services, and developing joint training programs.

Even the largest companies, with plenty of trainers on hand, are looking outward to meet worker demands for certification and portable degrees from high-quality institutions. More and more corporate universities are pairing up with accredited schools. Companies like Berlitz International, Ford Motor Company, General Electric and Xerox have certified their employee training programs so that their employees can earn college credit for training. This means workers can take their achievements with them to find jobs in other fields or geographic areas.

Motorola has long established relationships with universities and community colleges in every region in which it has a corporate presence, although it has its own university at its headquarters in Illinois. But now, it is establishing alliances in regions of the country where it anticipates launching new facilities. In Richmond, Virginia, where its new computer chip plant will be built, Motorola is working with **J. Sargeant Reynolds Community College** to recruit and train prospective employees. Instructors from the college are being certified to teach courses designed by Motorola University. This ensures J. Sargeant Reynolds a new crop of students.

The pressure to leverage resources is being felt across the board.

Responding to Market Forces

Increased demand for higher skills has spurred new initiatives to improve the access of employers and workers to training and to increase the portability of skills. What sets these initiatives apart is their reliance on implementation at the local level.

In Illinois, Governor Jim Edgar's office designed the **Prairie State 2000** program, which offers training vouchers to individuals and grants to small and medium-sized businesses. The premise of the program is that individuals and companies are in the best position to meet their own training needs. The program has hit a positive chord with many businesses pressing to keep up with technology improvements and related training demands. Preliminary findings show individuals receiving wage increases of more than eight percent during each of the first two years of the program. And employers are reporting high job retention rates for those workers who have been retrained.

Tennessee has taken a different route, based on the results of a startling survey that showed its workforce is both undereducated and undertrained compared to its 19 neighboring and regional states. In response, **Tennessee's SkillsNet** targets employers that have been hesitant, typically, to invest in workers who lack a solid foundation of skills. SkillsNet makes self-paced, computer-based classes available over the Internet. For a minimal investment, businesses can help adult workers improve their basic skills, and ultimately, their job performance.

A more comprehensive approach is the federally sponsored and locally executed **Manufacturing Extension Partnership** (MEP), which provides information, resources, and services to small and medium-sized manufacturers. MEPs use federal seed money to attract state, local, and private funding for a wide range of management services on a firm-by-firm basis. MEP workplace assistance activities often include helping firms to evaluate their training needs and to locate training service providers in the area. But MEP administrators are quick to point out that smaller firms are only willing to embrace training if they see it as part of a larger strategy to achieve business goals.

A recent national initiative on skill standards looks beyond the issue of access and seeks to improve the operation of labor markets. The goal of this congressionally sponsored effort is to develop broadly accepted measures of worker capabilities on an industry-by-industry basis. Since 1994, the National Skills Standards Board has attempted to build consensus on these measures by bringing together representatives of business, labor, academia, and community organizations. If national skill standards are successfully implemented, each of the players in the skills race should benefit. Business will be able to recruit and hire more effectively. Unions and workers will benefit from enhanced career and job opportunities. Educators and trainers will be better equipped to meet business requirements and to improve the school-to-work transition.

In all of these instances, the walls that have traditionally separated employers and schools, schools and learners, government and the private sector, are gradually breaking down. And what's emerging are interests, once narrowly defined, working together toward shared solutions.

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3 Formal training is generally defined as having a set curriculum and structure, whether it takes place in a classroom, lab, or via technology. Informal training, which is more prevalent, is spontaneous instruction that typically occurs on the job—one employee teaching a fellow worker how to perform a task. Source: Bassi, Laurie, The American Society for Training & Development (ASTD), using data from the Bureau of Labor Statistics, the U.S. Department of Education, the Economic Report of the President, and ASTD's Benchmarking Forum.

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Part Three

SUCCESS IN THE FIELD

The following pages detail some of the more creative developments in the field. From the best examples of collaboration, we distilled eight winning principles. The players involved have made real progress in preparing and retooling American workers, and raising their living standards in the process. They lead by example.

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PRINCIPLE ONE

No single business, group of workers, educator, or government agency can tackle the training challenge alone.

Intel Corporation: Community Alliances
Boeing Corporation: Training in Schools
Jane Addams Resource Corporation: Sharing Learning Resources
Manufacturing Extension Partnership: Helping Manufacturers Compete

It's not just a matter of a labor market that is competitive. Even those who are available for hire fall far below the hiring needs of employers.

To triumph in this very trying environment, Santa Clara, California-based **Intel Corporation** has pieced together a strategy with schools, government, and workers. Its effort in New Mexico is a leading example of a collaboration at work.

The arrival of Intel's pentium chip plant in the Albuquerque area meant substantial change for the previously quiet community. Its large workforce put new demands on a school district that lacked adequate revenues. To ensure the company's best understanding of New Mexico's priorities, Intel hired Bill Garcia, the State's former Secretary of Economic Development, to help forge a productive relationship with local officials. Garcia was an inspired choice: he had maneuvered well through the state's politics and agencies and had cultivated important relationships with grassroots organizations.

With a tie to the state, the company won a generous financial incentive package in exchange for a commitment to help the region improve its workforce development through partnerships with secondary schools and community colleges. It pledged, in turn, to build a new high school and to hire a minimum of 60 percent of its fast-growing workforce locally. To meet the hiring commitment, the company must beat some tremendous odds: a majority minority population with one of the highest illiteracy rates in the nation and a working population that is, on balance, unskilled. To attract new workers to the plant, Intel offers attractive starting salaries, stock options, bonus plans, education and training opportunities, and more. Intel's urgency and the state's priority has forged important community alliances including the high schools, community colleges, municipal government, and Intel's own management and employees.

Training in the Schools

Schools that adapt to market needs establish winning relationships with industry. This is seen in the case of the **Boeing Company**, a manufacturer in a cyclical business with a huge backlog of orders, a relatively senior workforce, and serious skill challenges that require immediate attention. The company has partnered with schools in an attempt to push some of its entry-level training — costing hundreds of thousands of dollars — back into the Seattle schools. In conjunction with the federal government and local schools, Boeing has worked an arrangement that refines the curriculum to suit Boeing's needs, although the skills it develops are portable to many other work arenas. The result: Boeing has a ready source of labor, and workers are better prepared for rapid technological change and can expect brighter earnings prospects.

After securing a grant of almost half a million dollars from the **National Science Foundation**, Boeing and other area manufacturers put together an applied academics program with a manufacturing specialty for distribution to local high schools. This tech-prep program feeds

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interested high school students into a manufacturing technology associate program at 13 community colleges and five technical colleges.

Students who take manufacturing technology courses in their junior and senior years of high school earn college credit that can be applied towards a two-year associate degree with participating colleges. During the summer before they graduate, selected students do internships at Boeing and other companies that introduce them to career opportunities in manufacturing, teach them basic factory skills, and assist them in selecting specialty fields within manufacturing.

The work pays off: after completing a year or two of community college, students are eligible to work at Boeing as entry-level technicians earning $27,000 a year. And Boeing gets proven workers who are already familiar with manufacturing and are therefore likely to be productive quickly.

> **"This alliance between business (Boeing), the union (the International Association of Machinists and Aerospace Workers), the state and federal governments, and our local colleges, is customer driven."**
>
> Harold Heen, administrator
> [illegible]
> [illegible]
> [illegible], Washington

Sharing Learning Resources

Not all companies are able or willing to commit the time and investment that Boeing is in Seattle. This is especially true for small firms. Some of the biggest barriers to training are the time and cost of just *researching* learning options. Generally, small and mid-sized companies are not willing do much on their own unless they see an immediate impact on their bottom line. There are ways to share the costs, however, and the best training alliances allow companies to pool their resources and to benefit from economies of scale. Both workers and companies benefit from a broader choice of training opportunities that would likely be unaffordable otherwise.

Not all alliances are company-driven. On the outskirts of Chicago, the **Jane Addams Resource Corporation** (JARC) has managed to create an informal network of collaborators. JARC is a community-based, non-profit training provider that receives funds from the state. Its expertise is in basic skills training for workers in the metal stamping industry. JARC's business clients know that training translates into improved productivity on the shop floor, and they are extremely loyal to the trainers.

In fact, although the firms compete in the same industry, they often collaborate on curriculum design and donate equipment to JARC for training purposes.

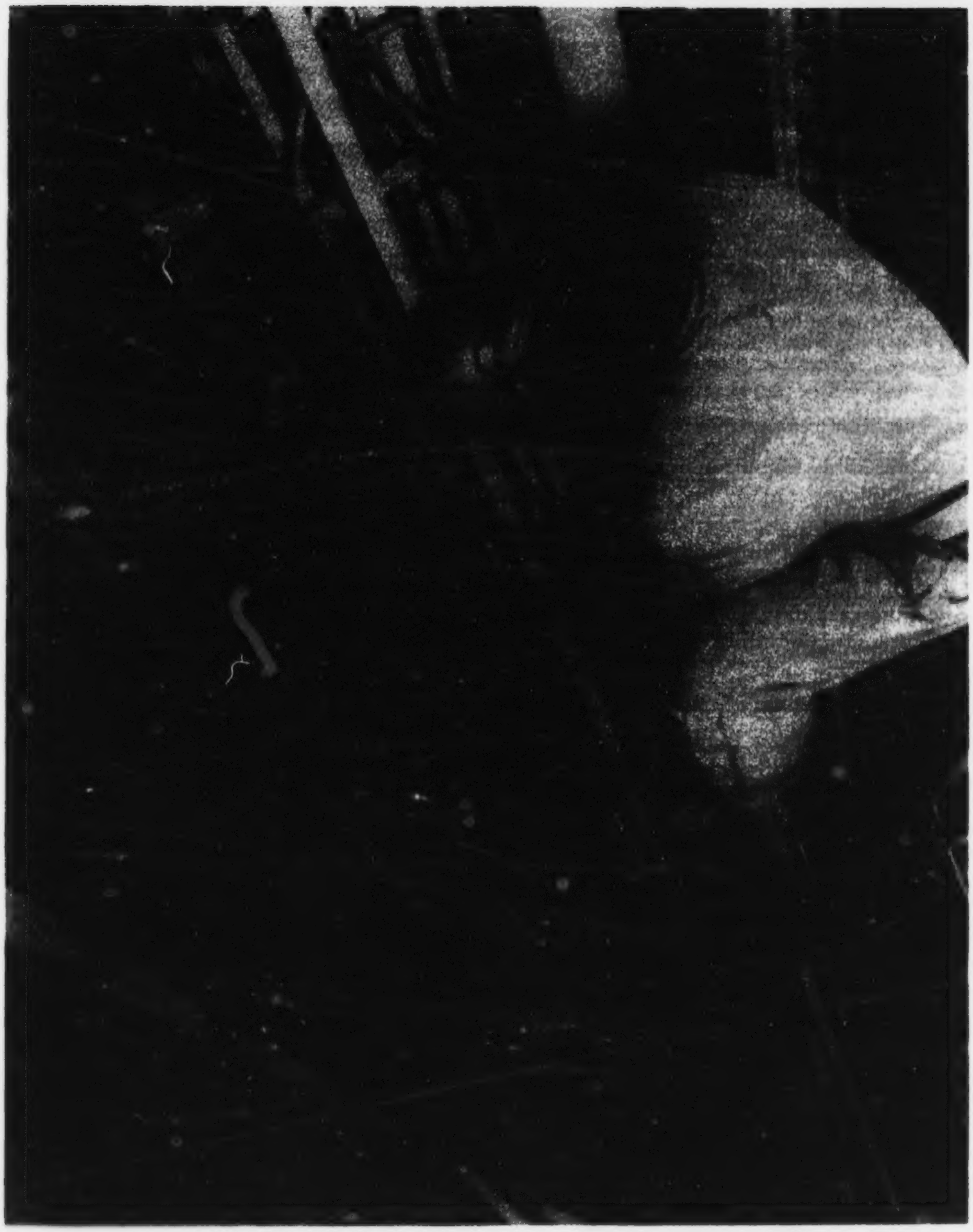
Basic shop skills are certainly transferable within the industry, but JARC finds that *the companies most generous with their* training do not lose employees because those workers are able to transfer to higher positions within their original companies.

Helping Manufacturers Compete

Partnerships can help small manufacturers that are struggling to compete. Because small companies are the foundation of many products sold worldwide, their capacity to produce goods reliably, and at a competitive cost, has direct bearing on the success of the larger companies that they service. And, of course, without that success, the small suppliers that form the backbone of U.S. competitiveness, would not exist.

The **Chicago Manufacturing Center** (CMC), part of the MEP system of centers across the country that help small manufacturers modernize their production capabilities, builds partnerships between local educational institutions and community and economic development groups in the Chicago metropolitan region. Because CMC gets private sector support and assistance from federal, state, and local government, it can offer its services at rates affordable to small companies. Despite the dramatic drop in the region's overall manufacturing employment over the past 15 years, a surprising number of manufacturers in the area must hire new employees for skilled technical positions. Since the average age of the typical manufacturing worker is quite high, many workers are eligible for retirement, opening up new job opportunities.

Some firms need assistance in ensuring the ongoing skill development of their current workforces. For instance, CMC helped **Chicago Metal Rolled Products** develop a companywide learning program that included basic education, job-specific training, and computer skills training. Like other businesses, the metal company has to accommodate a multilingual workforce: classes are taught in English, Spanish, and Polish. The program has paid off. Since it began, the company has generated 30 percent sales increases, and employment has jumped 20 percent. CMC and its community college partners do joint visits and engagements with clients, bringing a broader array of services than either entity could do alone. It also helps the colleges gain access to and understand how to work with the small manufacturer that is otherwise hard to reach. Together, CMC and the colleges develop education and training programs that are responsive to the unique needs of small employers.



PRINCIPLE TWO

All parties must buy into training for it to be effective; each player must have an up-front stake in designing and instituting continuous learning.

US West Communications and the Communication Workers of America: Working Together
Lockheed Martin Control Systems: Training for New Markets
Rockwell Automation's Allen Bradley and the United Electrical, Radio & Machine Workers of America: Retraining to Keep Jobs at Home

2

Training for High Performance

It used to be that employees entrusted major decisions affecting their work life to the organizations that employed them. The result was an environment that created a dependent employee. For employees today, responsibility is at a premium, with all levels of workers conscious of the reality that the quality of their work impacts the company's success. Increasing numbers of firms are nurturing employee initiative because they recognize that for workers to feel a stake in the company's success, they must be afforded a greater role in organizational decisions. Training figures prominently in this formula.

Workers are participating in quality circles, flexible teams, and continuous learning. They track company finances, thanks to open-book management, and suggest ways to trim costs. Companies offer employees the chance to enjoy incentives and share in profits if they meet performance standards and corporate goals. Because workers are increasingly responsible for the firm's success, they must advance their skill levels. High-performance workers need to be able to create and apply knowledge, to adapt and be flexible, and to work in teams with people of diverse backgrounds.

The payoff to high-performance restructuring is improvements for all: the company gains improved productivity and greater competitiveness; customers get better service and quality; the empowered workers earn higher wages. A national survey of nearly 1,000 companies finds statistically and substantively significant evidence that high-performance workplace practices produce lower employee turnover, higher productivity, and superior financial performance.[1]

An estimated one-fourth to one-third of U.S. firms have made some kind of high-performance changes.[2] On average, manufacturing firms have implemented more mechanisms for reorganizing work than have non-manufacturing firms.[3]

Research shows that high performance work practices are frequently accompanied by increased training. When addressing education and training, it is critical to balance the employer's interest in performance with the workers' desire to maintain job security and worker employability. Unions typically press for training programs designed not merely to enable workers to do their existing jobs, but to develop skills and abilities needed down the road.

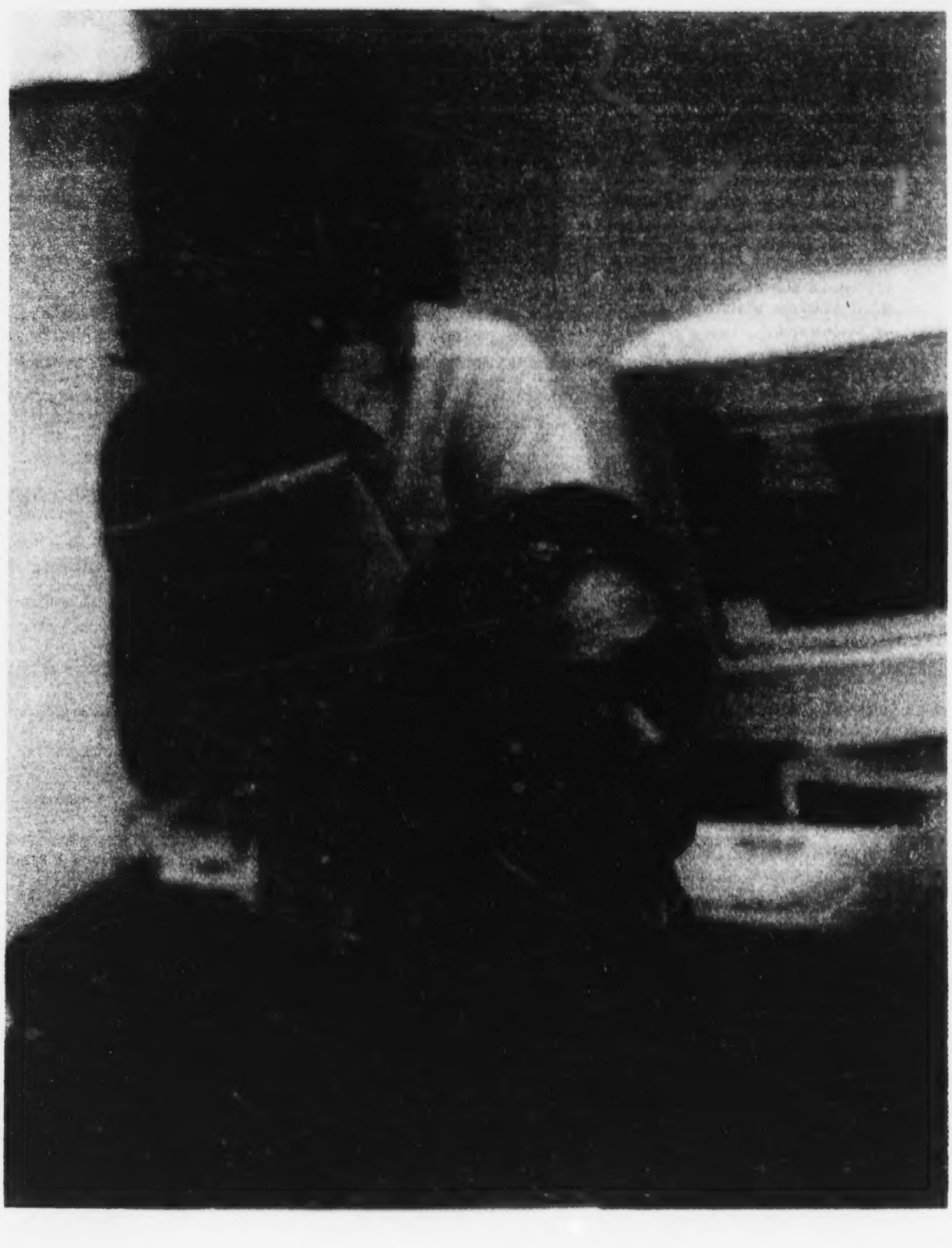
The minority of firms that have embraced high-performance strategies includes **US West Communications**, the largest of the "baby bell" telecommunication companies in terms of geographical area. In an industry that launches new products every six to eight weeks, US West faces stiff competition. The company has already undergone massive downsizing and streamlining efforts, but the 1996 Telecommunications Act brought additional challenges as new competitors threaten to infiltrate US West's territory. The company is under tremendous pressure to enhance productivity, lower expenses, increase quality, and boost sales.

Management has had a history of confrontation with the **Communication Workers of America** (CWA). Over the past decade, when it slashed payroll in a time of austerity and downsizing, relations were particularly strained. But in 1996, US West cooperated with the union to establish a new Internet-based training system. A joint management/labor decision-making body was given the task of streamlining the company's operations and increasing productivity. These changes would not have been possible if management had not taken the time to explain to workers the larger competitiveness issues in the telecommunications industry and given workers a role in the restructuring process.

This has been a formidable challenge, given that, typically, labor has spurned technology because it often means the elimination of jobs. But technology can also bring new opportunities to employees (both inside and outside the organization). US West workers were given responsibility for developing the tasks on the new online system — a logical move since the employees are also the end users. Both managers and employees quickly saw that worker feedback not only improved the program, but also gave workers a stake in its success. Additionally, trial runs by the users helped remove most of the bugs before the system was distributed to thousands of other employees.

Managers have been amazed by the improvements in efficiency. Employees now have more time to sell US West services since all the tools they need are at their fingertips on the company Intranet. Because it is easy to make content changes, the Intranet acts as a simple and consistent communications medium for employees. The company is ahead of the curve in web-based training, one of only a handful of large companies that makes all training accessible on the web.

> **"I went to JobLink classes when one of the plants closed a few years back. I got my GED and took a class in heating and refrigeration. I've got a new job at Inland now thanks to what I learned, and I'm telling others to take advantage of the opportunity to pick up new skills."**
>
> Ray Mendoza,
> union employee of Inland Steel,
> East Chicago, Indiana



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In this case, US West and CWA shared the responsibility for learning. Only when employer and employee have a stake in the results can companies bank on improved performance and employees acquire the necessary skills to advance in the labor market.

One of several top contractors for the Pentagon, **Lockheed Martin Control Systems** watched its sales plummet after the end of the Cold War. Both management and the 1,000 rank and file felt vulnerable, but the firm turned a downturn into a new business dimension. By the mid 1990s, this Johnson City, New York-based division of what has become the world's largest aerospace firm moved aggressively into commercial markets. Its goal was to integrate its knowledge of controls and other high-tech electronics, once geared toward military purposes in the air, into civilian use on the ground.

Early on, David Bessey, a management engineer with the company, recognized that Control System's conversion from defense to commercial markets would eventually pick up the slack caused by the downturn in military spending. When government contracting seemed in an irreversible slide, Bessey and his fellow engineers pushed upper management to build locomotive systems in plants that once churned out aerospace defense products. At first, they hit a brick wall: Control Systems built aircraft, and aircraft only, said company superiors. But soon the naysayers saw the potential of winning multi-million dollar contracts, and the firm began to apply defense-related electronic technology to new products. It designed hybrid taxis and buses, locomotive electronics, emissions and noise control systems, and electric cars. Within three years, 44 percent of its sales were commercial, compared with only five percent in 1991.

Bessey, involved in one of the company's most promising ventures, became a shining example of how other companies could make necessary conversions. He has been crisscrossing the country, leading seminars and networking with colleagues in the field who want to emulate Control System's success. Perhaps most exemplary in the Control Systems story is how Bessey and his coworkers have persuaded state and federal governments to help fund their project that brought new opportunities to would-be displaced workers.

The federal government saw the firm as a pioneer in efforts to convert its product for the commercial market and to protect the jobs of its employees. In 1995, the Federal Defense Diversification Program made the Control Systems group one of its 17 grantees by helping to pay for an intensive retraining program. That year it awarded Control Systems a $315,000 grant; in 1996 it made another $622,000 grant.[4] All told, the money helped to upgrade the commercial skills of some 450 employees whose jobs were in jeopardy. For the workers, the funds helped them retrain for new jobs. For the firm, it helped to create a future business opportunity: Lockheed Martin, the world's biggest defense conglomerate, may soon supply Amtrak with high-speed rail equipment

If the federal government played a vital role in Control Systems' earlier incarnation, with a steady demand for the defense firm's products, its endorsement of Control System's commercial transformation was essential to "converting" the workforce. But the linchpin in the company's ability was the buy-in of the workers who watched the downsizing of the aerospace industry and feared layoffs or closure of the manufacturing facility. Although they had to take a pay cut (the company had to bring wages in line with the private market), the workers were able to avoid being displaced altogether, and

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they gained new opportunities to learn marketable skills. Today the plant is well on its way to being profitable. Its training program, considered exemplary by other firms in its field, is perhaps the most widely discussed case study in the industry.

Retraining to Keep Jobs at Home

When management and workers collaborate to define the skill sets needed in the future, they design a more effective training system and heighten the value of learning. California-based **Rockwell International**, with operations in almost 80 countries, is constantly reassessing how and where it manufactures. Its largest automation division is Milwaukee-based **Allen-Bradley**, which designs, manufactures, and supports a broad range of products including logic processors, power and motions control devices, sensors, and software.

As this $4 billion automation unit struggles to determine where best to produce its products, it often comes head-to-head with its union, the **United Electrical, Radio & Machine Workers of America**. Logically, the union has an interest in retaining in Milwaukee those positions that increase skill development, reward greater responsibility, and provide enhanced career opportunities for incumbent workers.

A few years ago, Allen-Bradley agreed not to outsource certain high-skill, high-wage jobs if the union would submit to qualification tests to determine which workers were eligible for the jobs. The company and union pooled efforts to determine how to better prepare workers for advanced positions within the company. Management agreed to keep the test results confidential, allowing those who failed to re-take the test. Employees responded to testing demands because they saw that by doing so, they were helping to keep valuable jobs in Milwaukee, rather than at one of Rockwell's non-union facilities.

Council on Competitiveness

PRINCIPLE THREE

Effective training requires that all parties do their part: employers must provide learning opportunities; workers must devote the time and energy to learning; schools must teach marketable skills.

Wisconsin Regional Training Partnership: High Wages and Profits for All
Inland Steel Corporation and the United Steel Workers: After-Hours Learning
Pennsylvania College of Technology and Toyota: A Ready Pool of Mechanics
Albuquerque Technical Vocational Institute: Health Care Training for the Low-Skilled

3

High-Performance Work

The Wisconsin Regional Training Partnership (WRTP) is a jointly governed consortium established by business and labor leaders in support of high-performance workplaces and jobs with growth. Five unions — the United Auto Workers, the International Association of Machinists, the United Steelworkers of America, the United Electrical Workers, and the United Paperwork's International Union — and two dozen firms concentrated primarily in metalworking, electronics, and related durable goods industries, participate in the consortia. The Executive Committee is composed of an equal number of management and labor representatives and a smaller number of public sector representatives, including the state's labor secretary, and the directors of the area technical colleges and private industry councils.

The WRTP emerged out of the manufacturing sector's massive restructuring during the 1980s, when the job base shifted to the low-wage service industry. An unfortunate consequence has been a sharp reduction in living standards, given that service jobs pay about one-third less, on average, than manufacturing jobs.

The survival of those manufacturers that remain depends on their ability to acquire new technologies, develop new ways to organize work to spread responsibility and elicit employee participation, and draw on a skilled workforce.

In response, those employers formed WRTP to define job performance standards and the training necessary to ensure skill development. Management agreed to provide learning opportunities with the condition that labor would share the responsibility for improving performance. The local Waukesha County Technical College is helping to reconfigure the manufacturing education and training system so that training is easily accessible, offered at flexible hours, and is as individualized as possible. It's a worker-centered approach that more educators are using as they refine their own skills in providing workplace education and training.

External resources from state government and national foundations were critical during the start-up phase. Now, the WRTP is self-sufficient through local funding from training and modernization service providers. They have an interest in investing since WRTP boosts demand for increasingly sophisticated services and helps them achieve their missions. And member companies are taking an interest in training. Workers have increased their training hours and hiring is on the rise. State and local officials have also called upon the WRTP to troubleshoot problems that are common to employers across the state.

After-Hours Learning

Training doesn't just mean lecturing to workers or formal classroom instruction. Self-directed learning is fast becoming the most effective way to boost skills and incomes.

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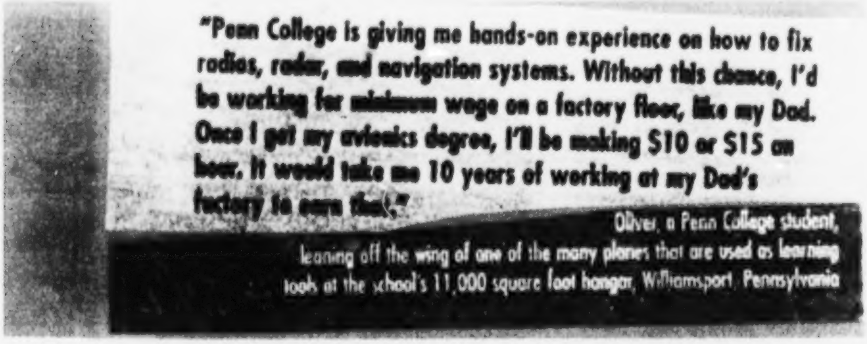
marketable skills.

At East Chicago, Indiana-based **Inland Steel Corporation,** many workers are acutely aware of how important this is. In the mid 1980s, Inland Steel began a volatile period of massive restructuring and layoffs. Downsizing, and all the worker anxiety that accompanies it, continues today. Not knowing what the future held for Inland or the industry, management wanted to give the workers a chance to expand their skills and knowledge on their own time. So **United Steel Workers Local #1010** prodded the company to set up a workplace skills program to better cushion workers from a hard fall. The result is JobLink 2000.



"Penn College is giving me hands-on experience on how to fix radios, radar, and navigation systems. Without this chance, I'd be working for minimum wage on a factory floor, like my Dad. Once I get my avionics degree, I'll be making $10 or $15 an hour. It would take me 10 years of working at my Dad's factory to earn that."

Oliver, a Penn College student, leaning off the wing of one of the many planes that are used as learning tools at the school's 11,000 square foot hangar, Williamsport, Pennsylvania

Inland Steel. Whether the classes are in wiring, masonry, computers, or small engine repair, they all incorporate basic skills. Carpentry math, for instance, involves working with word problems, reading a tape measure, reducing and computing fractions, and using a calculator. The company institutes pre- and post-tests to capture the results. After a Residential Wiring and Carpentry class, for example, some workers saw their math scores improve by as much as 1,900 percent! JobLink 2000 pushes workers to gain new portable skills and provides the company with performance improvements.

Although Inland funds JobLink 2000, the workers are responsible for registering for and committing time for the classes. Taught by instructors provided by a local suburban college, employees often take functional home-improvement classes in anticipation of future employment options at the company or outside. The workers are always wary of where they will be in the next corporate restructuring, and they are anxious to have income possibilities during their retirement. Some use the courses to start their own plumbing businesses, others pick up home repair skills as a hobby, others pursue employability in other departments of

Market-Responsive Schools

As the demand for continuing education expands into the workplace, higher education institutions are tapping into a lucrative market. **Pennsylvania College of Technology,** a wholly owned affiliate of Penn State University, is flourishing in Williamsport, a small community in northern Pennsylvania. Despite its remote, rural location, Penn College has secured strong partnerships with some of the world's major industries. Companies are so convinced of the school's ability to train workers, they are willing to donate major technical support, hardware, software, and other training materials to Penn College for general learning purposes.

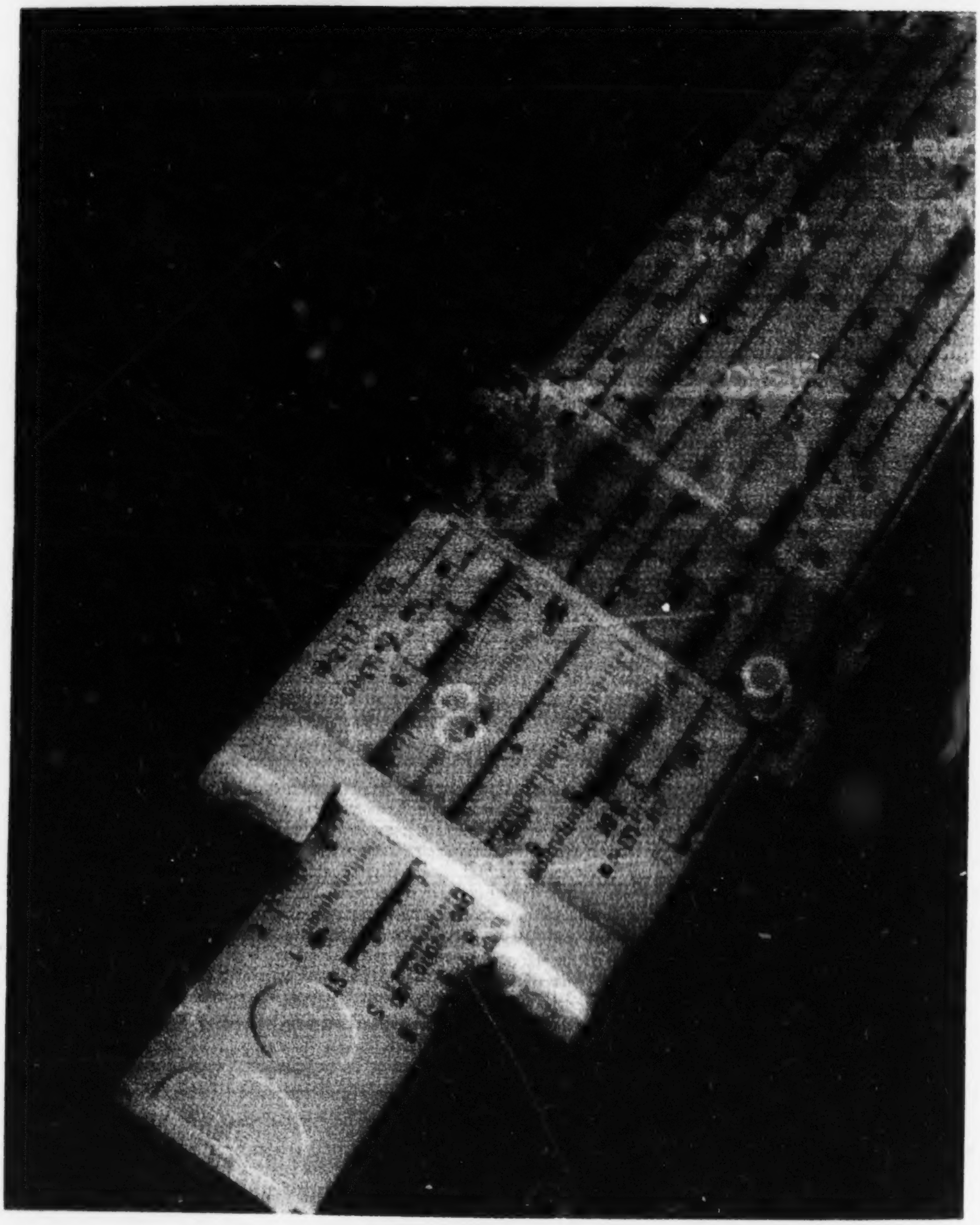
The United States-based manufacturing arm of **Toyota**, for instance, developed automotive classrooms at Penn College to enhance the school's transportation technology program. Since 1990, Toyota has been sending its employees to Penn College to learn the latest techniques. For the past seven years, Toyota has donated training aids, curriculum, and vehicles for the students to learn from firsthand. A simulated electrical system from a Toyota Camry is available for students to troubleshoot and repair problems. Given the technological advancements of automakers, repair work is central to a manufacturer's competitiveness. The investments in training are very worthwhile, say Toyota officials. Although the program's start-up costs totaled $300,000, the firm figures it made up the costs in the first year and can rely on the Williamsport school to churn out a ready pool of mechanics. The hands-on training pays off for students, who move easily into jobs after graduation.

The market responsiveness of schools is proving critical to local economies. Albuquerque's **Technical Vocational Institute** (TVI), already New Mexico's largest community college, is creating new business for itself with tailor-made programs for high-growth industries.

Those industries are desperate for workers in a state in which welfare dependency, high-school drop out rates, and illiteracy are way above the national average. The fast-expanding health care services, including New Mexico's hospitals and HMOs, are in a constant search for a wide variety of technicians. TVI is intent on turning out enough respiratory therapists to meet the growing demand. And the school is targeting a virtually untapped market for retraining: the unskilled and minimum wage workers stuck in dead-end jobs. It's a logical match: enrollment is open; tuition for general classes is inexpensive; classes are held at all hours; counselors are on hand to provide support services; and market demand for health care services will rise as the population ages.

With 100 percent placement rate of its respiratory therapy graduates, for example, TVI has engendered confidence and support from local business. In fact, the private sector has donated much of the lab's $100,000 worth of capital equipment, including state-of-the-art computerized systems that simulate respiratory failure. The clinical simulations help students refine their critical thinking and decision-making skills in life threatening situations. The American Heart Association produced a software package that allows students to receive nationally recognized certificates in basic life support and advanced cardiac life support without leaving the computer lab.

Strides made at Penn College in Williamsport and at TVI in Albuquerque, enabled in part by the support of government and private industry, create new skills and income opportunities for a whole new generation of workers.



PRINCIPLE FOUR

Education and training are not ends unto themselves; rather, they are essential means for creating worker employability, upward mobility, skills portability, and firm productivity.

DeAnza College's Occupational Training Institute: Matching Trainees with Jobs
Valencia Community College: Tracking Graduate Success
Michigan State's Human Resources Development, Inc.: Emphasizing Employability
Lansing Area Manufacturing Partnership: Opening Up Apprenticeships to Youth
Laborers International Union of North America: Giving Students an Eye into the Industry

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At **DeAnza College's Occupational Training Institute** (OTI) in Cupertino, California, education and training are seen as steps toward employment. OTI is designed to help dislocated workers and the economically disadvantaged enter (or re-enter) the workforce. These nontraditional students will only pursue education and training that promises to pay off in increased skills, new opportunities, and/or higher wages. To help motivate students to stay in school, OTI offers a wide range of employment-related services such as career advisors, study skills workshops, and job search training. Both before and during enrollment at DeAnza, OTI counselors help students make the vital connection between education and opportunities in the labor market.

OTI puts a priority on maintaining close relationships with major employers in the Santa Clara Valley region, and it frequently reviews those relationships to ensure that training programs meet the needs of the local market. Roughly 85 percent of OTI clients find employment after completion of training, with 75 percent moving into their chosen field.

Tracking Graduate Success

States are moving to simplify and consolidate workforce programs — ranging from training to job placement to welfare. This provides employers and workers ready access. Employers want a system that is easy to use and provides qualified job candidates. Job seekers need timely and reliable information about job openings and skill requirements. These new systems, governed by "workforce development boards," provide a host of services, but priority is generally on job search, counseling, and related assistance. Programs are increasingly being judged by how well they place participants.

Working on behalf of the broad central portion of the state, Florida's **Valencia Community College** has been bolder and more successful than its counterparts across the country in designing education/vocational programs that connect their participants directly to the jobs. The college entrusts the issue to an initiator. Susan Kelley, vice president of resource development and government relations, has determined from the outset that Valencia must lead the way in eliminating the overlap among and between federal and state agencies. Valencia was just one of many public and private sector partners in a five-county area in central Florida that designed a new customer-driven workforce education and employment system. The partners successfully consolidated activities of the Job Training Partnership Act (JTPA), one-stop career centers, and community colleges. The federal government sees this as a model that can be replicated around the country. Kelley has taken Valencia's success beyond the school's Orange County base. She pushes for statewide change and holds her school as an example. Through Kelley's public

Educati[illegible] are [illegible] proceeding[illegible]

efforts and tireless networking, she is nationally recognized and called on to share Valencia's strategies with colleagues across the country.

Community colleges in Florida and other states are beginning to survey employers on their skill needs and to track job placements of their graduates. To enhance the competition, the state publishes data from each participating college regarding its graduates' wage rates and job retention. This allows interested students to compare Valencia's results, for example, with other colleges and public schools. And it makes it easier for employers to locate training opportunities for their workforces.

Obviously, such responsiveness is a great multiplier for economic development. Companies can bank on expansion because they can dip into an adequate and ready pool of trained/trainable workers; students can expect to find jobs that match their skills; government can streamline and pare down costly programs — from outplacement centers to welfare coverage.

> **"We've got more jobs than we can fill. As a community college, we have the responsibility to provide students of all backgrounds and ages with the job readiness skills they need to move into high-demand jobs and be successful."**
>
> Mick Sullivan, provost,
> DeAnza College, Cupertino, California

Emphasizing Employability

Today's workers are taking more of an interest in their own learning, knowing that employability is key to their workplace success. In a heavily unionized state in which the economy has undergone dramatic changes, **Michigan State's Human Resources Development, Inc.** (HRDI) exemplifies how organized labor can be instrumental in developing innovative ways to boost workers' skills. Michigan HRDI serves many clients by providing technical assistance on employment and training issues to labor, industry, and public sector agencies. Aligning with employers that need workers, the non-profit organization ensures that in the education and training process, employment is the final result.

Written off a decade ago as a Rust Belt state, Michigan has in recent years hit record highs in jobs created and new lows in unemployment. The gyrations in market demand have created new challenges in workforce preparation. If the 1980s were the days of painful downsizing for General Motors (GM), Ford, and Chrysler, now the Big Three are trying to squeeze all the available production capacity out of existing plants. After exhausting layoff lists and the jobs bank, the three automakers are now faced with overwhelming recruitment, screening, hiring, and training challenges. The Big Three estimate that between 1995 and 2003 nearly one-half of their hourly workers may need to be replaced as some 260,000 skilled workers enter or are eligible for retirement. Even though the companies offer generous pay and benefit packages — the average Big Three employee earns $43 an hour in total compensation — this will be a struggle.

Anticipating this hiring boom, labor is taking action by developing school-to-work programs that introduce automotive careers to high school students. For example, the **Lansing Area Manufacturing Partnership** (LAMP) is a school-to-work program in which students learn about production-level union jobs through work-based learning experiences on the floor of GM plants in the Lansing area. To ensure that the union was fully involved, GM largely turned over to the United Auto Workers (UAW) responsibility for developing the curricula with a vocational-technical center that serves 12–13 local school districts in the Lansing area. GM and UAW see this as a national model that will be replicated.

The unions are also devising "school-to-registered apprenticeship" programs. A new law on the books has sparked interest in registering high school students as apprentices. The Michigan State Legislature passed a $2,000 tax credit for businesses that take on a registered apprentice (union or non-union). The $2,000 can help firms cover such costs as wages or training tools for apprentices, and many firms are taking advantage of this incentive.

The unions recognize that the lack of qualified entry-level workers is hurting their ranks. In particular, one of the construction industry unions, the **Laborers International Union of North America**, is hoping that by giving students an early look at the trade and the benefits of being unionized, it will later be able to recruit students into the union. That union is one of the players involved with giving students in Lansing and Detroit the opportunity to participate in work-based learning experiences, along with the state's Bureau of Apprenticeship Training, the Michigan Department of Education, and the Michigan Jobs Commission. The union loaned work space to the students, even though the students are not required to join the union to participate.

The apprentices-in-training work full-time over the summer before their senior year of high school and part-time during their senior year. They return to full-time work after graduation, while they also pursue a post-secondary degree at a nearby community college. The work hours count toward the required 6,000 or 8,000 hours of training time they have to log to become state-registered apprentices.

PRINCIPLE FIVE

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Learning helps accomplish worksite goals when it is convenient and available in smaller, more targeted increments.

Stevens Institute of Technology's Advanced Telecommunications Institute and Bell Atlantic: Learning Online
Boeing Company: Just-in-Time Training
Disney University: Training as Teams
Xerox Corporation and the Institute for Research on Learning: Integration of Learning and Work
DeAnza College: Degrees in High Demand
Western Governors University: Convenience Education

Across the Hudson River from New York City, **Stevens Institute of Technology** has put together a very effective coalition. The Hoboken, New Jersey-based institution is one of the country's oldest private technical colleges and one of the best examples of how a university can become a vibrant contributor to workforce development. Stevens' **Advanced Telecommunications Institute** (ATI) operates with funding from government and industry. Supported by the Bell Atlantic and Transwitch corporations, ATI is a highly developed laboratory to research the latest telecommunication technologies. It breaks down into three components: research and development; technology transfer from the college laboratory to industrial circles; and educational programs, from short-term technical courses to promote staff development to full master's and doctoral programs.

Students at the Stevens Institute are helping **Bell Atlantic** to use technology as a workplace learning tool. By developing an online, multimedia course that company electricians can access remotely from any web server, workers don't have to leave their work to attend class at another location. The company saves time and travel expenses. Technicians and engineers who are often on the road benefit from just-in-time learning that can be dialed up from any desktop computer. Highly visual lessons, replete with easy-to-follow graphics, on how to do new service installations, for example, can be learned at the very place where the installation is needed. Workers can simply use the online support as a reference. And other online classes help keep them up to speed on the latest developments in the industry, yet they do not require users to take in all the information at once.

Learning Just-in-Time and at Work

Although corporate universities abound, there is a clear trend away from subject-driven, off-site, classroom-style training and toward job-specific, on-site, just-in-time training. It is getting harder to sell training in the traditional two- or three-day seminar format because the compression of time mandates that learning be convenient and customized. Increasingly, employees who need job-related information will pull up online repositories and extract the appropriate data. At the **Boeing Company**, factory workers already consult such brief videos for instant illustrations of many tasks involved in building airplanes. Computer-based learning breaks down traditional courses into learning "nuggets," giving the learner just what he or she needs to perform and just when it's needed.

Other organizations are training their employees in their normal work teams to ensure that lessons learned can be applied immediately. The informal interaction between workers often reinforces learning and is more likely to result in performance improvements. A few years ago, **Disney University** realized that too many

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employees were not retaining and applying the skills they learned during training. The trainers concluded that too much of the learning took place in classrooms far away from the actual work site. So training was restructured and now focuses on helping an entire work team learn as one unit, on-site. In addition to job-related training, Disney's performance consultants offer courses in the important social dimension of work effectiveness: conflict resolution, listening skills, and other interventions designed to help work units operate smoothly.

> **"More and more, industry-led curricula are determining the kinds of technical degrees people are earning. Community colleges have been pretty quick to adapt, and they are learning how to accommodate industry needs. We've worked to shorten programs, and we're looking for new ways to change curricula."**
>
> Bill Garcia,
> public affairs manager,
> Intel Corporation,
> Rio Rancho, New Mexico

The Institute for Research on Learning (IRL) specializes in understanding how people learn and designing strategies and practices for effective learning. Founded in 1987 as a national non-profit center by Xerox, IRL recently helped **Xerox** to rethink its training practices for the company's customer service center in Lewisville, Texas. The customer service representatives were frustrated that they didn't have the knowledge they needed to meet customer needs. For years, the company had relied on old systems of customer profiles that segregated customer service, billing, and account inquiry and phone support. Integrating the three departments into a single unit would require the staff to learn multiple jobs.

With the help of IRL, *phased interactive learning* was introduced in September 1996, allowing workers to learn in a communal environment and to apply training as they progressed. Instead of undergoing weeks of training on how to answer customer calls, representatives were taught the basics in a classroom and then allowed to start taking real calls to get a feel for the job. Workers were given a chance to apply lessons, coach peers, and interact in the real workplace setting, which minimized time away from work and encouraged a supportive social structure. By fostering the proper work environment and by leveraging the learning that naturally takes place in small work groups, the company improved work processes and boosted morale at the same time. In addition, millions in recurring savings were documented as customer and employee satisfaction increased.

Degrees in High Demand

Just-in-time also means that schools and vendors are shortening their classes, making them more flexible and task-specific. **DeAnza College** in Silicon Valley offers a medical technician program that has minimal entry requirements and is designed to place graduates quickly into positions in the health industry. Instead of having to attend school for two years to earn an associate degree, students can be certified in just one year.

DeAnza designed the curricula in 1990 in response to growing private sector demand for trained workers, and the college is successfully turning welfare recipients and dislocated workers into employable workers. Enrollment immediately jumped 300–400 percent when the "time to degree" was shortened. But employers need workers so quickly that they cannot afford to wait one year. Now DeAnza is under more pressure to make the learning time shorter and to offer mini-certificates that can be earned in just one-quarter's worth of classes and work experience (12 weeks total).

The ultimate in convenience education is the newly developed virtual **Western Governors University** (WGU). Like other learning institutions hoping to attract a host of diverse learners, WGU is making learning available "anytime, anywhere," and offers many options. Bypassing traditional classrooms, WGU uses advanced technology to expand educational opportunities to reach a wider array of students using courses from multiple institutions. WGU is not expected to supplant the traditional campus setting; rather, it has set its sights on the would-be students wishing to return to school and those disenfranchised from the higher education system. WGU is breaking new ground by requiring students to demonstrate competencies — not to log seat time — to earn a WGU certificate or degree. *Where* learning takes place will no longer be as important as *what* a student actually learns.

Courses will be available through various media, including CD-ROMs, the Internet, interactive video, e-mail, satellite, and 500 television channels. An Internet-based catalog will not just list various courses. The catalog is designed to help students assess their existing skills and knowledge and determine what courses they need and are prepared to take.

PRINCIPLE SIX

Technology-based learning can improve accessibility and reduce cost, but it is not a complete training strategy by itself.

IBM: Connecting Employees
Sun Microsystems: Classroom Training Fills a Need
Hewlett-Packard and Stanford University: Interactive Classes
National Technological University: Distance Learning That Hits Home
Maricopa Community College: Degrees on the Net
Pacific Gas & Electric's Technical Learning Services: Simulated Drills
Andersen Consulting and the Institute for the Learning Sciences: Multimedia Self-Study
U.S. Robotics: Making Computers Fun
Dartmouth College's Amos Tuck School: Wired: A Competitive Edge

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The development of interactive technologies is transforming the way workers learn and how companies do business. The percentage of people currently using information technology directly in their jobs has tripled since 1970.[4] And more and more firms are using computers to deliver education and training. No longer are annual seminars and training sessions the only means for employees to improve their skills. Instructional technologies that emphasize group work, problem solving, and collaboration are increasingly available. Simulations, while costly, are often the ultimate tool.

Many companies see technology solutions as less expensive and more effective than traditional ways of providing learning. For firms with workers scattered across time zones, technology is an ideal way to reduce costs. Flexible delivery choices expand the reach of training beyond costly training facilities, which require workers to travel and lose work time. Distance learning options reduce the cost of instructor and student travel, while broadening access for many other workers who may not otherwise be able to participate. Technology brings learning to the desktop or workstation so that it is available when and where employees need it.

However, technology solutions are not a natural fit for all work-site training. Classrooms provide invaluable interaction, teamwork, and remediation opportunities that neither firms nor schools are willing to part with. At least not yet.

Integrating Technology

The now commonplace computer has changed the way organizations operate; nearly 60 percent of employed workers under the age of 50 already use a computer at work — and usage continues to grow. The indirect, but rising costs of training, such as travel and off-site classes, are pushing companies to make training accessible from the desktop and integrated with work. Naturally, this relies on a computer-literate workforce and puts even greater pressure on firms to bring workers up to technological speed.

More and more companies like IBM are vigorously pursuing ways to bring learning to the personal workspace. In the United States, about 55 percent of IBM employees are "teleworking" in some way — working from customer locations, home, or elsewhere during some part of the working week. That makes the smart, timely use of technology even more important in the effective delivery of skill development and continuous learning opportunities. Employees take responsibility for their own employability, and IBM provides the supporting tools and resources.

The company estimates that three-quarters of its training budget goes to

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Technol[illegible] learni[illegible]rove acc[illegible]d r[illegible]

cover employee travel time and lost work hours alone. It can no longer afford to send its far-flung employees to training when learning can be brought to the desktop. An audio-enabled computer with web browser is the key tool, because learning via computer reduces costs associated with instructor/student travel; puts instructor expertise to better use; and allows teams of workers to collaborate, compare, and enhance their own performance. For employees seeking career counseling, self-assessment tools, and other professional development workshops, the company has devised a National Career Fitness Intranet website that is available to all its workers, anytime and anywhere.

IBM's subsidiary, Lotus Development Corporation, developed "Learning Space," a complete technology solution that combines the benefits of distance learning with the collaborative advantages of a traditional classroom. Classes still have instructors and regular assignments, but interactive discussion databases allow students and teachers to share information, work in teams, and ask and answer questions. A traditional class that takes five days might be extended over 20 days time, making it easier for workers to join training at their convenience. Additionally, because LearningSpace is based in Lotus Notes, which is an integrated software package being rolled out companywide at IBM, learning will also be available on demand for all employees at the click of a button. Tutorials and quick help boxes give just-in-time hints to workers, regardless of whether they are enrolled in any formal online classes.

By 1998, IBM plans to have 40 percent of its training in the United States be technology-based.

Sun Microsystems, which has developed many of the core networking technologies at the heart of the Internet, sees web-based learning as a way to augment, not replace, classroom learning. Sun uses technology to cover basic material, but

> **"We're building strategic partnerships with universities. Look at the top five business schools in the country. That's who we want to develop a distance learning program with."**
>
> – Jayne Parker, director of organizational development, Walt Disney World Company, Lake Buena Vista, Florida

its employees still logged 20,000 instructional classroom hours in 1996. It is particularly striking that Sun, one of the most advanced technology firms in the country, believes that classes offer an invaluable human factor that technology cannot provide.

Technology Options

Technology has the potential to bring training closer to the user and can be very valuable in certain circumstances. Learners like it because it offers greater convenience, immediate feedback, and the opportunity to determine their own pace. Organizations like it because it reduces learning time, provides a consistent model, and is easy to update. Technology comes in many forms, each with advantages and drawbacks:

Computer-based Training (CBT) has been around the longest and is used for some applications by roughly a third of U.S. organizations with more than 100 employees, according to *Training Magazine's* 1997 *Industry Report.*[7] CBT is essentially one method of presenting training, using information drawn from a hard drive, laser disc, or CD-ROM. Computer-based lessons often help users learn faster and remember *more* compared to instructor-led training. In particular, the use of CD-ROMs as a delivery platform for CBT has increased.[8] CD-ROMs can incorporate large media files without fear of network bottlenecks, but the drawback is that course content becomes obsolete quickly and cannot be updated. And many firms find that CBT is not adequately customized to company needs. Often organizations have no choice but to buy off-the-shelf versions because they are unwilling to pay the high development costs of customizing in-house.

Distance Learning is a delivery method that allows learners to "attend class" at locations remote from the point of instruction using a variety of media (including computer, audio, and video). Distance learning is popular because it provides students with access to the most skilled teachers in the world. But it does require a large number of people to be cost-effective, and the up-front investment makes it unaffordable for most firms.

Palo Alto, California-based **Hewlett-Packard** has found a low-tech way to provide distance education. To maintain the most cutting-edge workforce possible, the company encourages its employees to pursue further study at the post-graduate level by making **Stanford University's** engineering and computer science classes available on-site and at no cost. For the Palo Alto-based workers, courses are provided via a television network.

When Hewlett-Packard moved its microwave division to Santa Rosa, California, north of San Francisco in 1972, the new site was out of television range. Stanford agreed to videotape the lectures and to send them to Santa Rosa. For each class, a full-time Hewlett-Packard engineer was chosen (and approved by Stanford) to be course facilitator. The facilitator is responsible for leading the students in discussion for and ensuring that the class works as a group.

Stanford's Dean of Engineering saw this new mode of teaching as an opportunity to set up an educational experiment comparing the effectiveness of attending class, watching via television link, and receiving videos. Stanford has collected data for every single quarter over the past 25 years, and it has found some astonishing results: the students who are taught with "tutored videotape instruction" consistently *outperform* campus-based Stanford students and others learning via television.

Although low-tech, this learner-managed method is practical. Learners can hit pause during the videotape lectures if they miss a point or want to review for clarity. Hewlett-Packard students stop the tape approximately every three to five minutes throughout the entire lecture. This is truly accessible learning — available in small increments and just-in-time.

Some teachers are changing the way they teach when they go on-line — acting more as moderators than as teachers in the old-fashioned pedagogical sense. **National Technological University** (NTU), the leading university for satellite delivery of advanced technical education, regularly broadcasts seminars to firms. To make the coursework as applicable as possible, NTU staff visit participating companies ahead of time to get a sense of how the lessons can be applied to each firm and tailor their broadcasts appropriately.

Internet-Based Training delivers individualized instruction over computer networks and is displayed by a web browser. The biggest advantage to using the Internet over computer-based technology is that it is easy to update without recalling diskettes or reprinting CD-ROMs. The information is therefore current, timely, and consistent. Courses delivered via the web require only a modem and Internet access. Because the Internet connects people in virtual communities of learners, it is expected to not only be the medium of choice in the near future, but to fundamentally change learning. However, currently limited bandwidth capabilities make it unable to handle large media files. Undaunted, the **Maricopa Community College** system in Arizona is expecting to offer an associate of arts degree entirely over the Internet in the near future. Company *Intranets* (simply the Internet deployed within the company and protected with firewalls) are significant training vehicles.

Computer learning environments can also be used to simulate the operation of actual equipment or real-life experiences. *Simulation* allows users to learn from their mistakes on-line, before they are thrown into work environments that have high risks or where cost and consequence of error is high. **Pacific Gas and Electric's Technical Learning Services**, for example, invested in simulation trailers that park right outside the power plants, allowing workers to run through the drill of shutting down a plant just before they actually do it themselves. And companies do not have to take valuable resources off-line for education and training. But because the technology is so sophisticated, simulators are exorbitantly expensive, and very few firms have made the investment.

Andersen Consulting is an exception: it spent $2 million to have Northwestern University's **Institute for the Learning Sciences** develop a 15-module, multimedia self-study program that trainees take at their respective local offices. The international firm was spending so much money on travel and lodging just to shuttle people to training, that it found the investment worthwhile. And the learn-by-doing approach of the self-study program helps Andersen trainees grasp concepts more easily. If designers of simulation technology could establish a common platform for simulation that could be marketed widely, and therefore less expensively, more companies could use this valuable training resource and refine it to their specifications.

While the consistency and convenience of technology-based training are indisputable, there are still large barriers: development time and cost. Organizations need to research their options carefully when investing in technology to ensure that it meet their needs. Not all business cultures are ready for CBT. **U.S. Robotics***, a Chicago-based manufacturing firm, has instituted a company Intranet to help workers build computer skills and the comfort level to be able to maneuver through computer programs without fear.

And technology-based options are only part of a larger education and

* U.S. Robotics merged with 3-Com on June 12, 1997

training design for most firms, colleges, and government agencies. The American Society of Training & Development's Benchmarking Forum has found that 70 percent of the time, large companies still use traditional classrooms to deliver formal training.[9] While 300 colleges and universities offer virtual degrees, the vast majority require time on campus.[10] The government has been using technology to deliver training for years, but many courses remain classroom-based.

Technology clearly has a vital role in the education and training approaches of many firms and schools across the country. One of the very real potentials of technology is not to replace classroom learning, but to address the everyday learning needs of those individuals who are not making it to classes.

Getting Schools and Teachers Up to Speed

Clearly, technology will play a greater role as large numbers of firms and schools demand learning in shorter increments. Just-in-time learning is catching on and technology can bring learning opportunities to the desktop. Business schools are beginning to get in on the action, with top schools competing to be the most technologically sophisticated. **Dartmouth College's Amos Tuck School** recently invested 20 percent of its annual budget on a technology renovation. Still, of the nation's 700 business schools, only about 35 offer M.B.A. degrees partly through remote instruction.[11]

And the greatest technological inadequacies are in the nation's secondary schools, where both up-to-date physical equipment and properly trained instructors are sorely lacking. It does little good to provide classrooms with technology if the teachers are unable to use it effectively. To best serve students, teachers themselves must sharpen their technology skills. But many teachers at the K–12 level and beyond are not being trained how to use technology as a learning tool before they are certified to teach. While schools had 5.8 million computers (about one for every nine students) in 1995, fewer than half of the teachers regularly used computers in their instruction. Only 10 percent of new teachers in 1994 felt that they were prepared to integrate new technologies into their instruction. Fewer than half of experienced teachers had participated in professional development on the uses of new technologies.[12]

PRINCIPLE SEVEN

Performance measurement strengthens training by increasing accountability and transparency.

Sun Microsystems: Training Profitably
Pacific Gas & Electric: Performance Consulting
Massachusetts Career Centers: Quality Service

7

In all aspects of business, there is a drive to get more for less, and the training area is no exception. Some firms have rigorous evaluations in place to ensure that every training dollar is spent effectively. Because the best training benefits the company's bottom line, the shift from simply offering training to evaluating performance improvement is one of the most important developments in the field.

But measuring performance has been challenging for many companies. It's much easier to measure the number of training hours and scores on training tests than to capture the effects of training on performance.

At **Sun Microsystems**, in Silicon Valley, training equals profits. A leader in computer network technology, Sun's product lines change every six months. That makes continuous learning opportunities absolutely critical. Yet, Sun has managed to make its training profitable. Business units within the company can get training from the corporate university, known as SunU. But if SunU falls short of what the training needs are, Sun departments can go to outside vendors. So SunU has become fiercely competitive. Its offerings are so popular and effective that SunU is now turning a profit on its training programs for Sun employees. In 1996, with a budget of $4 million for research and design of learning materials, SunU brought in $21 million in revenue. Because of its remarkable success in recovering its costs, the university will not receive any Research & Development funding up-front from Sun Microsystems in 1998.

[illegible]

Performance measurement requires firms to evaluate how training leads to the transfer of skills, improves performance, and accomplishes specific business goals. In many firms, training is often recommended without first understanding why performance is not being achieved. A firm must be able to clearly state its business objectives and metrics for success. **Pacific Gas & Electric** (PG&E) is a model example.

A few years ago at PG&E, Technical Learning Services (TLS) embraced the concept of "performance consulting." Rather than referring workers to training without first assessing the problem, TLS sends performance consultants out into the field to get a first-hand look at work processes and to recommend appropriate interventions. It relies less on academic models of classroom learning, and prefers more practical learning opportunities at the 14 plants scattered all over the utility's 70,000 square mile territory.

The TLS program taps into the plants "best and brightest" workers to fill the performance consulting jobs. PG&E understands that for training to be effective, the consultants must understand both management and worker perspectives. Greg Thwing is one of those pulled from the rank and file to serve in management. He knows how to troubleshoot on the factory floor and is acutely aware of worker sensitivities. As a veteran dues-paying union member, he brings instant credibility to management. And he can enlist workers to develop the changes management seeks.

TLS has had tremendous success in using methods that are far less expensive than traditional classroom learning to

PRINCIPLE SEVEN

Performance measurement strengthens training by increasing accountability and transparency.

develop employee skills just-in-time and for use on the job. Like SunU, PG&E's TLS is strictly accountable. Because training budget allocations were replaced by a billable hours system, TLS has to prove its value to, and remain current with, the various business units within PG&E that buy its services. For every dollar invested in performance consulting in 1996, TLS was able to document a savings of $3.50. Not surprisingly, TLS has now become the prototype for other technical schools at PG&E and a model for other industries across the country.

Effective Measurement Tools

Research shows that learning adds immediate value to both the individual and the organization by raising wages, productivity, and/or profits. Studies show that a year of formal on-the-job training raises wages for non-college youth as much as a year of college. And increased company-provided training can raise productivity of a business by 16 percent or more.

> **"The best measurement of our training success is built in. That's because all Sun departments must pay for Sun training and rationalize the cost. If they don't like us, they can go to outside suppliers."**
>
> Thomas Edgerton,
> National learning architect,
> Sun Microsystems,
> Mountain View, California

But most human resource professionals are struggling with how to measure the return on investment in training and education. Although companies, schools, and governments are all under increasing pressure to demonstrate results, progress has been slow in developing effective tools that define, measure, and improve training results. Even members of the American Society for Training & Development's Benchmarking Forum — made up of large companies that invest heavily in education and training — are not likely to apply strict evaluations of training. Only 11 percent of forum member courses were evaluated in terms of skill transfer to the job in 1996. Just two percent of courses were evaluated for business impact. The success of those companies that do invest heavily in workforce development may well be the most illustrative.

Customer-Driven

Some state-run programs are demonstrating their value by competing directly with other learning providers. **Massachusetts Career Centers**, the state's new one-stop shops for employment and training funded by a $11.6 million grant to the state from the U.S. Department of Labor, are customer-driven, outcome-focused, and locally administered. But the state doesn't automatically operate the centers. State agencies must compete with private firms for the Career Center contracts, and the winners must then compete for clients. The system is guided by the state, but administered locally by Regional Employment Boards consisting of business, labor, education, government, and community leaders. These local boards have the power to configure the operations as they please. Instead of a state-run monopoly of one-size-fits-all centers, a variety of non-profit, for-profit and public organizations run the Career Centers at the local level.

Because Centers are commissioned for a period of no more than three years, they are held accountable for their performance and customer — that is, both employer and the job seeker — satisfaction. Centers that perform inadequately must improve quickly or go out of business.

And one-stop career centers are cost effective. By eliminating the waste and duplication of the old system, which spent well over $100 million each year to provide services throughout the state, Career Centers has succesfully streamlined the system. Massachusetts estimates that the roll-out of the centers across the state will cost $60 to $70 million and will provide better quality service. Here is an obvious measure of success: a survey of 200 Massachusetts businesses revealed that 82 percent of owners or personnel managers would be likely to use a Career Center, while only 3 percent were likely to use any of the employment programs that were formerly offered by Massachusetts public agencies. The reason: the Career Centers can offer users a faster and more tailored response.

PRINCIPLE EIGHT

The best training strategies not only meet short-term needs, but anticipate change and take early action.

Ameritech Ohio: Moving Ahead in Skill Standards
Latest Technologies: Technical Skills of the Future
Western Governors University and Motorola: Expanding Access and Portability
NYNEX, the International Brotherhood of Electrical Workers, and the Communication Workers of America: Sending Workers Back to School

8

What's Ahead?

Leaders like Jodie Glore often guide organizations and provide the necessary leadership that anticipates change. One of the best ways to become distinguished as a leader is through community outreach. Whether supporting the arts center, revamping the high school math and science curricula, or instituting flexible hours to accommodate broader family needs, Glore is always looking to make **Allen-Bradley** an employee-friendly company and Milwaukee a livable city.

But a dynamic personality is not enough. All players must understand the challenges ahead and begin taking action now to ensure worker readiness.

Hungry for workers, **Ameritech Ohio** is taking practical steps to establish skills standards by working with the Cleveland Chamber of Commerce, area community colleges, and other local organizations to help train workers for entry-level jobs throughout the communications field.

The goal of the Ameritech skills program is to organize recruitment and training processes that will create a flow of qualified workers into two occupational tracks in which workers are always in high demand: customer service representatives and communication technicians. Ameritech and other Cleveland employers with similar needs are developing skill standards, incorporating them into existing community college curricula, and offering work-based learning opportunities to spark student interest in these occupations. Participating employers are expected to hire students who successfully earn related associate degrees, meet skill standards, and pass company-specific employment tests.

Although Ameritech has driven the focus on workforce development for its own stock of employees, the company is sharing the benefits with the greater Cleveland community. In fact, some of Ameritech's direct competitors are hiring from this new pool of workers. But Ameritech knows that it has a better chance of preparing entry-level candidates by being part of a joint initiative than by going it alone. Cleveland firms are now spending less to hire more and have lower attrition rates since the student skills match industry needs. Schools are getting much needed assistance from Ameritech and other companies. And students know that if they meet the standards, they are ensured jobs in the local community. The program is easily replicable, and Ameritech plans to take it to other community colleges across the country.

Additionally, Ameritech is looking into developing a welfare-to-work training program to bring the unemployed coming off the rolls into customer service positions at Ameritech and other industries. Customer service is a major entry-level position, and many companies would benefit from an enlarged labor pool. With unemployment so low in the Midwest, Ameritech and other firms will have no choice but to help raise the skill levels of the unemployed to fill their openings.

Technical Skills of the Future

Trying to build the technical skills the manufacturing industry will need five years out, **Lucent Technologies Foundation** established a manufacturing workforce collaborative. Leading the effort are a consortium of advanced technology centers at post-secondary schools across the country known as the **National Coalition of Advanced Technology Centers** (NCATC) and the **Iacocca Institute at Lehigh University**. The NCATC, a coalition that helps industry keep pace with new and emerging practices and equipment with support services and the transfer of technology, will distribute the Lucent-funded curricula nationwide to its 94 community college members in 36 states.

> **"People are our long-term advantage. The key is to get them in the door and then make them better. But to do that we've got to help schools prepare enough people for highly skilled manufacturing jobs. That's critical to our competitiveness."**
>
> Jodie Glore, president
> Rockwell Automation Allen-Bradley
> Milwaukee, Wisconsin

The technical curriculum includes a broad range of technical and workplace skills. In addition to a necessary comfort level with computers and technology, tomorrow's factory floor workers will need decision-making, teamwork, and benchmarking skills.

The program is designed to be dynamic. By using the Internet and document-sharing software, this virtual education network will make it easy to adjust courses to accommodate new requirements. This gives educators and manufacturers fast access to high quality, "off-the-shelf" courses that they can integrate into existing academic and training programs.

This means valuable economies of scale; because courses meet industry standards, manufacturers and educators will not have to invest time and resources to develop their own. Further, those who learn, regardless of whether in the classroom or via distance technology, will be able to easily transfer their skills within the industry.

Skills Development: Expanding Access and Portability

State leaders are throwing their political clout behind the revolutionary Western Governors University (WGU), which will offer a new way to deliver higher education and training. As mentioned earlier, what makes this virtual university unique is that it coordinates the needs of corporate education and individual lifelong learners by drawing from coursework that universities and corporations have already demonstrated to be effective.

In anticipation of exploding population growth in western states, the 18 governors are investing in technology rather than additional bricks and mortar to serve the expected surge of students. Realizing that one policy maker alone could not successfully remove the barriers of regulation, bureaucracy, tradition, and turf, the governors have bonded together to pioneer this innovative concept of a virtual education. Governor Leavitt of Utah sees the change as inevitable: "We simply must align our public policies with what is occurring in the marketplace. Eventually, the inexorable forces of advanced technology will drive many of the changes contemplated in the WGU. But we can make the transition faster, and in a more organized fashion — and with less disruption to and more collaboration with traditional institutions — if all segments of society concerned with education cooperate in this development." [9]

Technology-based teaching and learning are a potentially powerful means of making educational services much more widely available. As employees take on additional training responsibilities, they are likely to demand that corporations award them with credentials certifying their skills, knowledge, and relevant experiences. To have a certificate in hand gives an employee an important credential when looking for another job opportunity inside his or her firm, or in another company where the skills are also valued.

Motorola is presently training more than 140,000 workers annually in the discipline of microelectronics/computer chip manufacturing. While the skills they are learning are highly useful and marketable in today's business environment, the workers do not receive portable credentials. So, in response to demands from their rank and file, Motorola, Intel, Micron, and other companies are looking to the WGU to develop courses for their employees, complete with assessment methodologies.

The fast pace of workplace change requires that firms take a forward-looking approach to learning. Its absence will inevitably mean a loss in productivity. Companies that are left scrambling to bring existing workers up to speed and to fill available positions quickly recognize that their human resources are a key competitive advantage. Rather than discard and replace employees, some companies are taking steps to build tomorrow's workforce with today's existing payroll.

NYNEX* and its two unions, the **International Brotherhood of Electrical Workers** (IBEW) and the **Communication Workers of America** (CWA), have partnered with community colleges across New York and New England to offer union employees the opportunity to acquire an associate degree in applied science with a focus on telecommunications technology. The company wants to expand worker knowledge already accrued through in-house training and job experience and to bring a higher level of skills to an increasingly demanding marketplace.

Known as the Next Step Program, it is a four-year educational program delivered at 25 community college campuses, on company time and at company expense. Selected employees attend class one day a week and work four days a week. All the while they continue to receive a full week's pay. At the end of the training, NYNEX workers are entitled to a higher wage. Workers gain valuable technical competencies and general employability skills including teamwork, customer focus, quality, and communications skills.

Most of the colleges participating in Next Step initially lacked the capacity to provide state-of-the-art content, and the faculty were not up on the latest industry changes. NYNEX and its unions worked closely with all faculty to focus the Next Step curriculum around relevant technical skills and knowledge, while also emphasizing customer focus, teamwork, project leadership, and critical-thinking skills. All students and faculty receive laptop computers on which they can communicate, prepare assignments, and simulate laboratory exercises, thereby creating a virtual learning environment that extends well beyond the reach of the traditional classroom.

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* NYNEX merged with Bell Atlantic on August 15,1997

This curriculum customization and enhancement of faculty knowledge has been accomplished through a series of faculty institutes and other developmental opportunities sponsored by NYNEX.

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PICKING UP THE PACE

Communities across the United States are making great strides in the skills race through alliances of business leaders, workers, educators, and government agencies. Their cooperation produces striking results when the partners break out of their old roles to focus on making connections—across organizations, across town, even across the country.

The examples of success documented in this report show that while the shortfalls in workforce preparedness are national in scope, the race is won locally. Conditions are too varied and time pressures too great for a grand design drawn in Washington. But government can contribute vision and resources and create vital links among partners.

The lessons drawn from coalitions that work can and should be applied across the nation. Before any of us can become part of the solution, one has to consider: What is my individual stake? Who shares my concerns? When these questions have been answered, one can determine: What can I contribute? How can I tap into resources?

By creating learning opportunities, for example, employers can engender the loyalty and commitment of their workers and can enhance the prospects of their own business. By articulating their skill needs to educators, firms can give students an early look at career opportunities.

Schools, in turn, need to be responsive to the skill needs of employers. By establishing strong links, secondary and post-secondary institutions can not only direct their graduates to higher-paying jobs, but also equip them with a solid foundation for further skills development. If properly applied, the nation's world leadership in information technology will give educators a clear edge in preparing workers.

Workers, often led by unions, can take an active part in making their own training more effective. After evaluating their own capabilities, they can commit the time and effort to their own advancement, and look to the future with anticipation, not anxiety. Only a joint employer-employee commitment to training will work in today's environment.

Government agencies at all levels can ensure that public investments in education and training meet actual market needs. This means providing reliable information to workers and employers, tailoring programs to local conditions, and adopting performance-based funding that ensures training providers are held accountable for the quality of their services. Government is uniquely positioned to benchmark and share best practices.

What we need most are coalition builders who can bring players together. Employers and schools can make great headway by identifying self-starters and giving them the power to lead by example. CEOs who look beyond senior management know that some of the most effective change agents may be far down the ranks or even outside the organization. Joined by leaders from companies, unions, and community colleges, government officials can send a clear message to the public that collaboration is vital.

We are at a natural point to confront the skills challenge. The economy is booming; job creation is high; unemployment is low; real wages are on the rise; and welfare rolls are shrinking. We may be in the strongest position ever to effect change. But if we miss the opportunity, demographics and global competitive pressure will work powerfully against us.

Already, we are preoccupied with keeping our aging workforce up-to-date and flexible and with training too many new entrants to learn in remedial classes what they should have mastered in school. There are high hurdles ahead. We have to pick up the pace to clear them.

What we need most are coalition builders who can bring players together.

Task Force

Chairmen

Richard Notebaert
Chairman and CEO
Ameritech

George Becker
President
United Steelworkers
of America

Harold Raveché
President
Stevens Institute of
Technology

Members

Marvin Bailey
Vice President, State
Technology Programs
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Ed Bales
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Wendy Belsky
Senior Vice President
Chase Manhattan
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About the Council

Who We Are

The Council on Competitiveness is a nonpartisan forum of 140 corporate chief executives, university presidents, and labor leaders working together to set a national action agenda to strengthen U.S. competitiveness.

The Council defines competitiveness as our nation's capacity to produce goods and services that succeed in international markets while maintaining or boosting the real incomes of U.S. citizens.

How We Operate

The Council shapes the national debate on competitiveness by concentrating on a few critical issues. These issues include technological innovation, workforce development, and the benchmarking of U.S. economic performance against other countries.

The Council focuses on two major initiatives a year. Members and Council staff work together to assemble data, develop consensus-based recommendations and implement follow-up strategies in every region of the country. This approach allows us to combine rigorous policy analysis with the practical insights of leaders from industry, academia, and organized labor. In addition, chief executives from more than 40 of the country's most prominent nonprofit research organizations, professional societies, and trade associations contribute.their expertise as national affiliates of the Council. Our work is guided by a 25-member Executive Committee. A full-time staff of 13 provides research and operational support.

Publications

1996 Competitiveness Index: *A Ten-Year Strategic Assessment*

This tenth-anniversary report assesses U.S. gains and vulnerabilities in competitiveness over the past decade. The report explores U.S. gains in recapturing global market shares, growth of per capita GDP, the reduction of both the budget and the deficit, and job creation. Top leaders in business, education and labor provide personal commentaries. October 1996 ($25)

Endless Frontier, Limited Resources: *U.S. R&D Policy for Competitiveness*

The report examines research and development trends in six key industry sectors, provides policy guidelines to meet the challenges confronting the stakeholders in America's R&D enterprise, and sets the agenda for a national discussion on the future of R&D by focusing on industry/ government/university partnerships.
April 1996 ($25)

Highway to Health: *Transforming U.S. Health Care in the Information Age*

A follow-on to the Council's NII applications conference, this report illustrates how the NII can be harnessed in conjunction with market forces to address the need to control costs at a time when the demand for health care services is rising. It identifies the principle barriers preventing the development of four robust health care market segments—"Remote Care," "Individual Health Information and Management," "Integration of Health Information Systems," and "Health Care Research and Education"— and recommends steps to overcoming those barriers. March 1996 ($25)

Building on Baldrige: *American Quality for the 21st Century*

This report reviews the effectiveness of and gives recommendations for the continuation and expansion of the Malcolm Baldrige Quality Award program in promoting quality principles and practices. July 1995 ($5; copies)

Human Resources Competitiveness Profile

This report looks at a life cycle approach to competitiveness and human resource issues in four areas: family and early childhood, primary and secondary school education, university education, and training. U.S. performance in these areas is compared with other countries.
April 1995 ($15)

Breaking the Barriers to the National Information Infrastructure

The third in a series of policy documents, this report highlights the Council's September 7-8, 1994, NII applications conference. It lists and examines the barriers users are facing in manufacturing, education, electronic commerce, health care, and entertainment in order to set the stage for a more constructive national policy debate.
December 1994. ($25)

Critical Technologies Update 1994

An update from the Council's Gaining New Ground report, this document re-evaluates America's performance in 94 critical technologies. September 1994 ($10)

Economic Security: *The Dollar$ and Sense of U.S. Foreign Policy*

This report analyzes eight case studies involving recent foreign policy decisions, with emphasis on export controls and export sanctions, and tallies their cost to the United States in terms of lost exports and jobs.
February 1994 ($25)

Competition Policy: *Unlocking the National Information Infrastructure*
The second in a series of NII policy reports, this statement offers the best thinking from a broad cross-section of the private sector on the competitive pressures driving the evolution of the U.S.-based communications industry.
December 1993 ($25)

Roadmap for Results: *Trade Policy, Technology, and American Competitiveness*
This book examines the U.S. government's ability to address the trade problems of high-tech industries. It documents the failings of the current trade policy process and recommends a new approach.
June/July 1993 (Book: $40; Report: $25)

Vision for a 21st Century Information Infrastructure
The first in a series of NII policy reports, this statement defines information infrastructure, assesses the U.S. position relative to its foreign competitors, and addresses the roles of government and the private sector.
May 1993 ($15)

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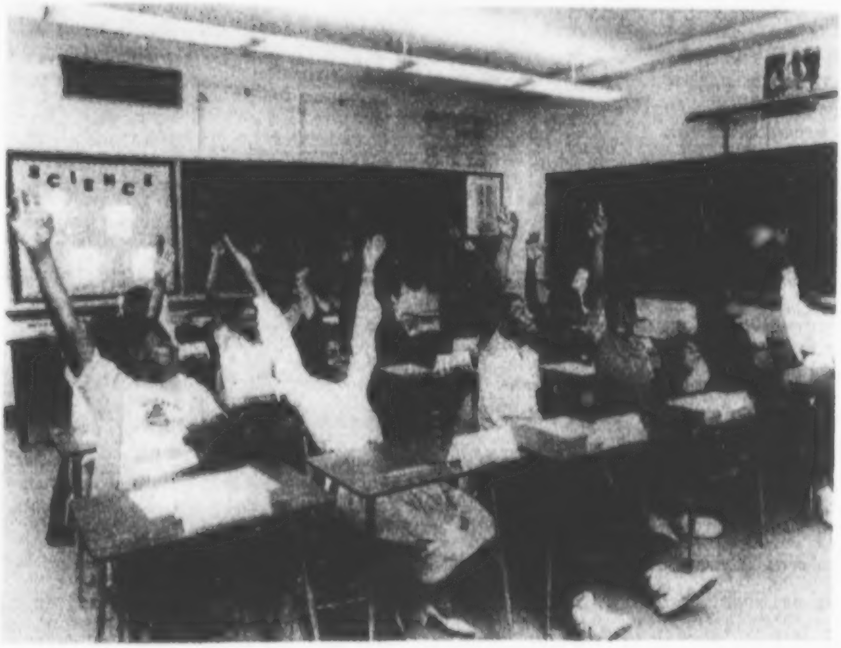
Do you speak this language?

$$\sum_{\alpha=1}^{\square} \boxed{\mathrm{Log}_{\beta}(\beta^{\alpha})} = 6^{2}$$



These sixth graders speak it fluently.

project SEED

Gottlieb, Myndii

From: Patterson, Wayne [WPatterson@cgs.nche.edu]
Sent: Friday, April 02, 1999 10:53 AM
To: Gottlieb, Myndii
Subject: RE: Enjoyed Meeting You Yesterday

Dear Myndii,

See below.

Wayne

****
*   *
* Wayne Patterson   *
* Dean in Residence   *
* Council of Graduate Schools   *
* One Dupont Circle NW, Suite 430 *
* Washington, DC 20036   *
* Ph: 202-223-3791 FAX: 202-331-7157 *
* wpatterson@cgs.nche.edu   *
*   *
* Current data from the study on   *
* graduate certificate programs can *
* be found at: *
*   www.cgsnet.org/summary.pdf *
*   *
****

> -----Original Message-----
> From: Gottlieb, Myndii [SMTP:Myndii.Gottlieb@mail.house.gov]
> Sent: Friday, April 02, 1999 10:36 AM
> To: Patterson, Wayne
> Subject: RE: Enjoyed Meeting You Yesterday
>
> Wayne,
>
> Thank you for all of your information. Again, I apologize for leaving
> early.
>
> I have skimmed the materials enclosed in the folder for the solution
> to the
> equation on the cover & can't find it. Could you point me in the
> right
> direction?
>

[Patterson, Wayne B.] Of course you know I can't tell you the answer! But let me see where we can start. Do you know what

logb (ba)

(or, if your email reader can't intepret the symbols above)

log (base BETA) (BETA to the ALPHA power)

is?

> Thanks again. I look forward to seeing, either on video or in person,

```
> a
> Project Seed classroom in action.
>
> Truly,
>
> Myndii Gottlieb
>
> -----Original Message-----
> From: Patterson, Wayne [mailto:WPatterson@cgs.nche.edu]
> Sent: Friday, April 02, 1999 7:50 AM
> To: Gottlieb, Myndii; Rodriguez, LauraR; Eule, Steve
> Subject: Enjoyed Meeting You Yesterday
>
>
> Dear Myndii, Laura, Steve:
>
> I wanted to say that I enjoyed very much meeting with you yesterday,
> as
> did Hamid. Also, thank you for the copy of the Hearings on the
> Statewide
> Systemic Initiatives programs.
>
> We look forward to further meetings, and we are certainly available at
> any time that you may need us.
>
> Best regards,
>
> Wayne
>
> ****************************************
> *                                      *
> * Wayne Patterson                      *
> * Dean in Residence                    *
> * Council of Graduate Schools          *
> * One Dupont Circle NW, Suite 430      *
> * Washington, DC 20036                 *
> * Ph: 202-223-3791 FAX: 202-331-7157 *
> * wpatterson@cgs.nche.edu              *
> *                                      *
> ****************************************
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